Diboson production and Standard Model Higgs searches with the ATLAS Detector at the Large Hadron Collider

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Production Rates at Hadron Colliders

Tevatron timeline

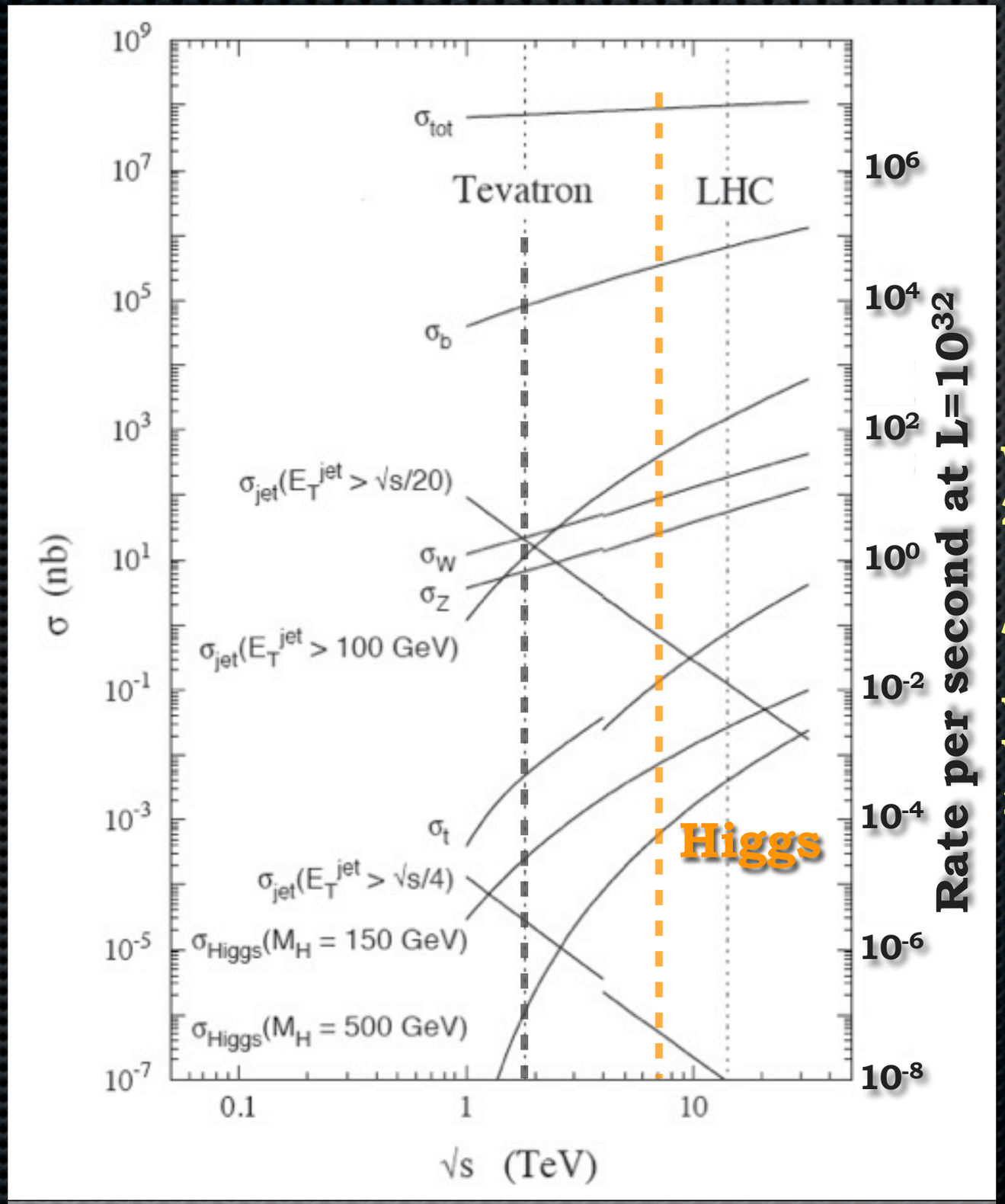
Particles$_{charged}$: 1988

jets$_{inclusive}$: 1989

W: 1988
Z: 1988

Top: 1994

WW: 2005
WZ: 2007
ZZ: 2008



ATLAS timeline

Apr 2010

May 2011

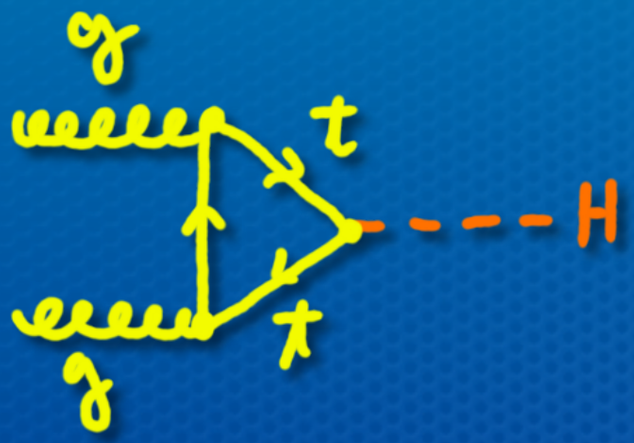
W: May 2010
Z: Jun 2010

Top: Dec 2010

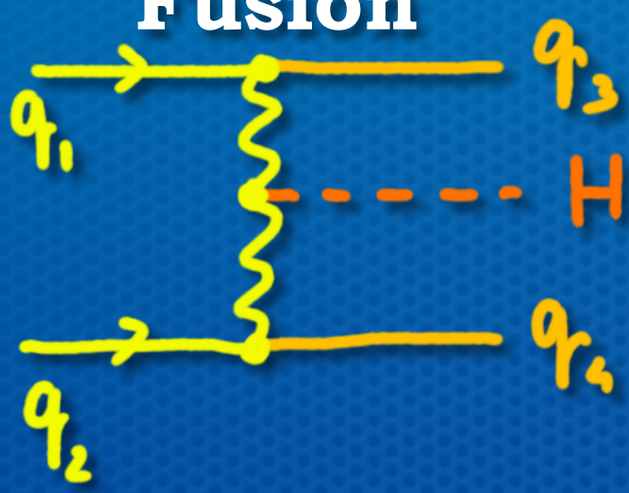
WW: Dec 2010
WZ: Mar 2011
ZZ: Jul 2011

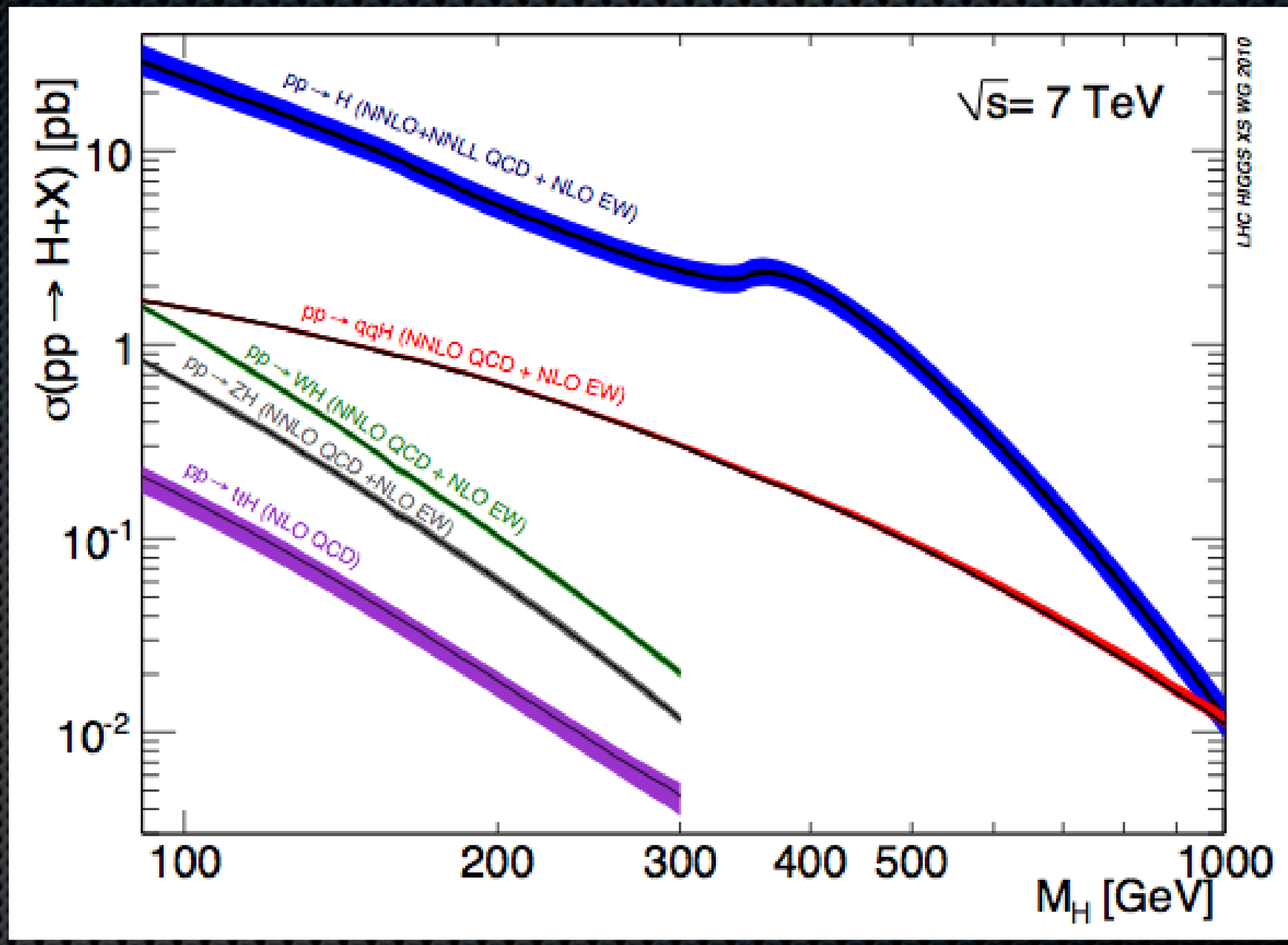
SM Higgs Production at LHC

Gluon Fusion

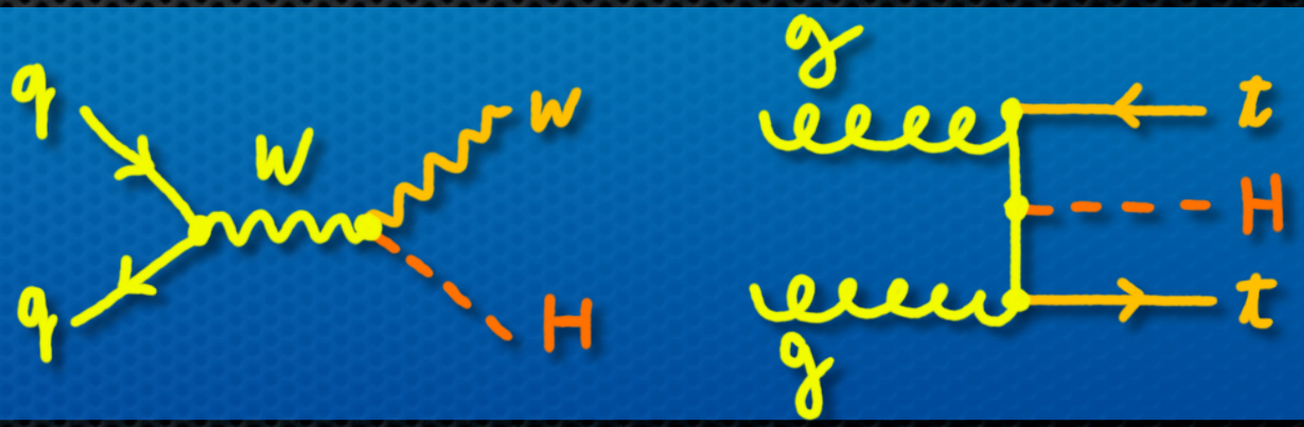


Vector Boson Fusion



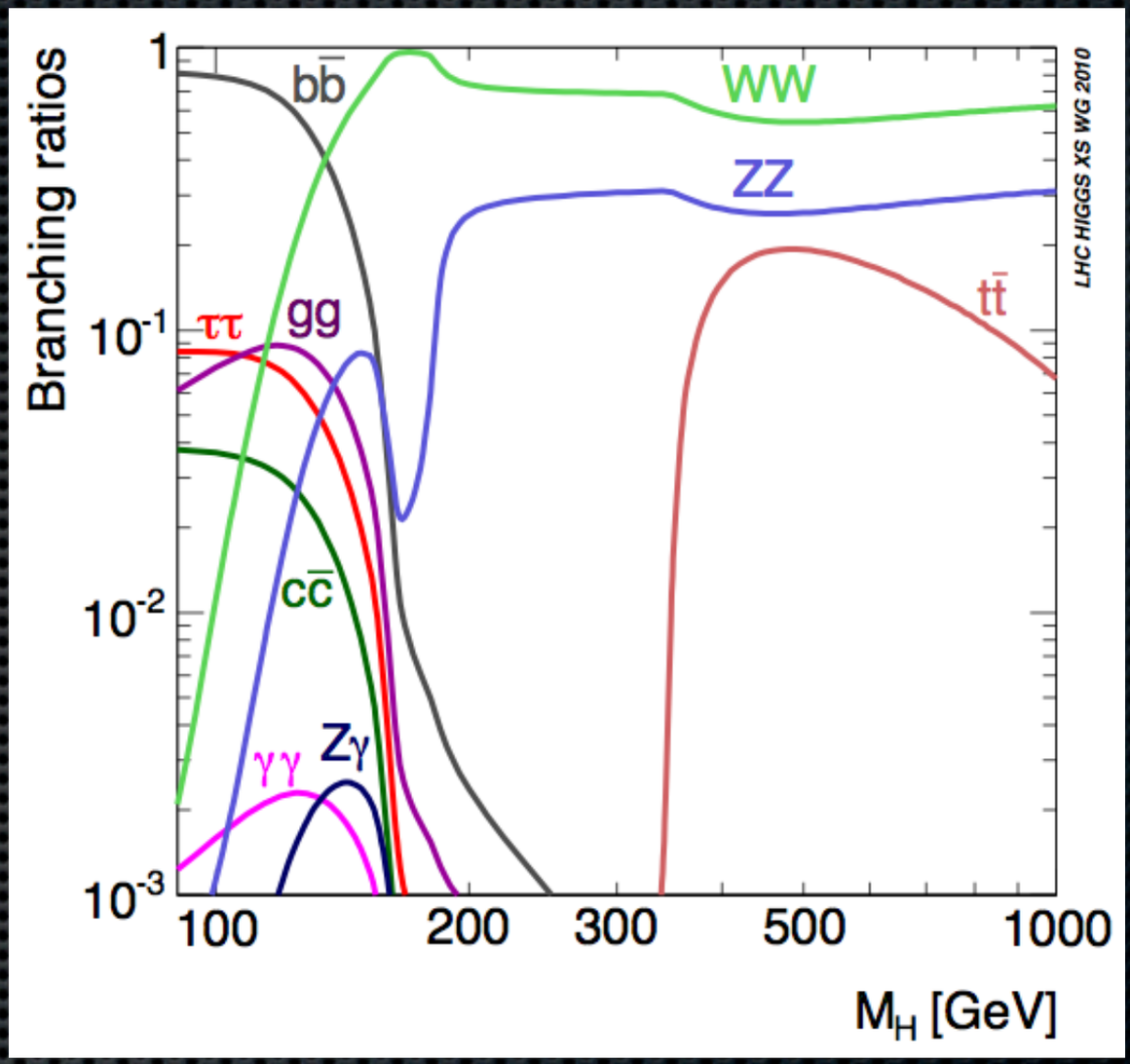


Associated Production



SM Higgs Decays ⇒ Analysis Channels

	Comment
$H \rightarrow \gamma\gamma$	Rare
$H \rightarrow \tau\tau$	Good S/B
$W/Z + (H \rightarrow bb)$	Higgs properties
$H \rightarrow WW \rightarrow l^+\nu\ l^-\nu$	Intermediate Mass
$H \rightarrow WW \rightarrow l\nu qq$	High Mass
$H \rightarrow ZZ \rightarrow l^+l^-\ l^+l^-$	Golden channel
$H \rightarrow ZZ \rightarrow l^+l^-\ \nu\nu$	High Mass
$H \rightarrow ZZ \rightarrow l^+l^-\ qq$	High Mass



Outline

Dataset: Up to 2.3 fb^{-1}

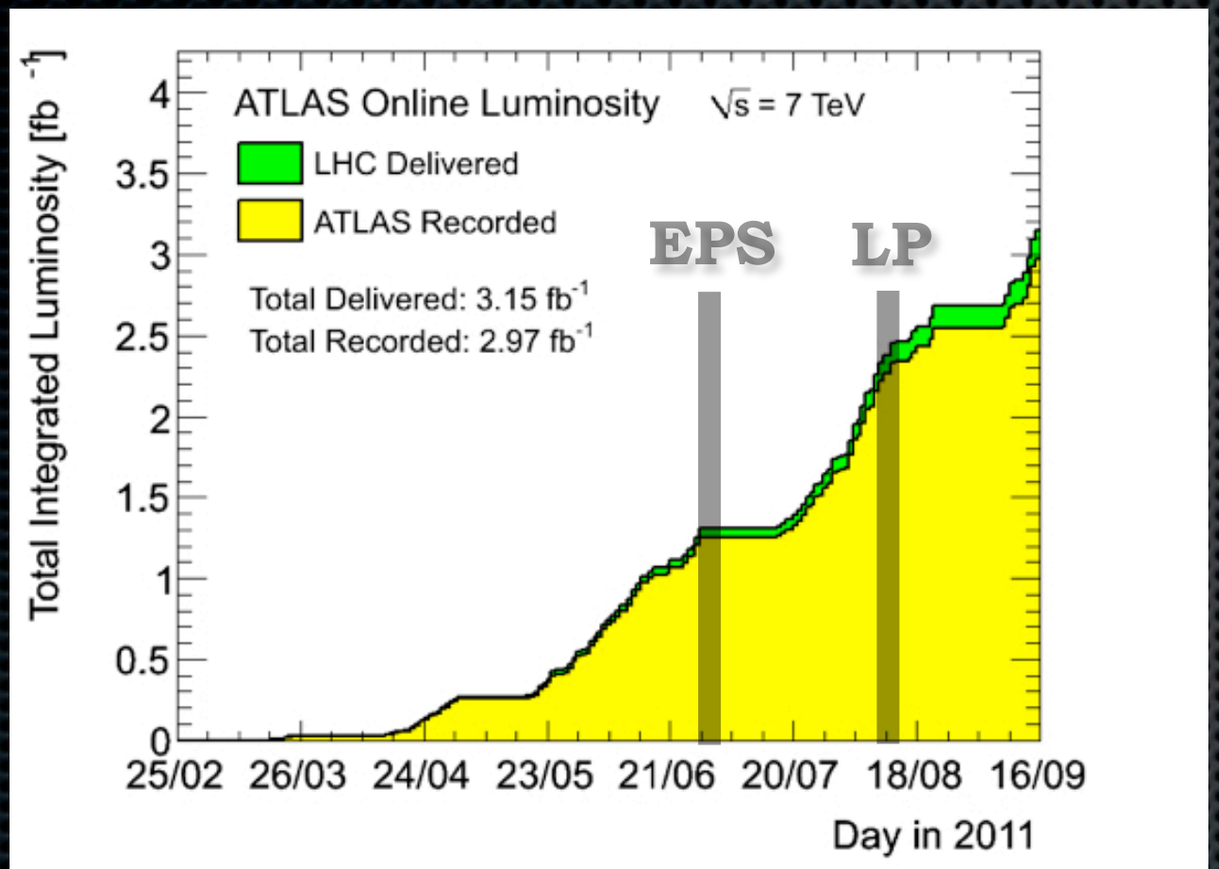
- **SM diboson production cross sections**

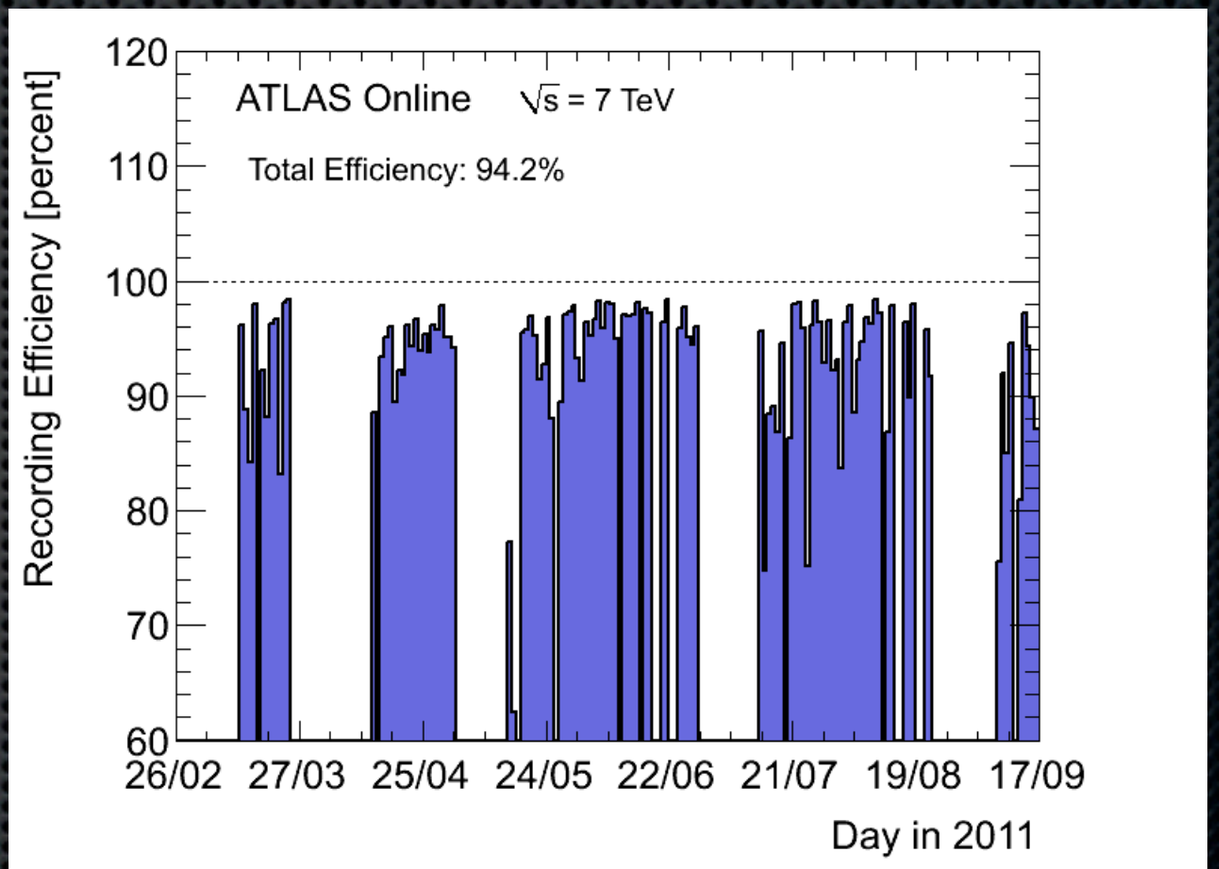
	$\mathscr{L}$ (fb^{-1})
$\gamma\gamma$	0.037
$W\gamma/Z\gamma$	0.035
$WW \rightarrow l^+\nu\, l^-\nu$	1.02
$WZ \rightarrow lll\nu$	1.02
$ZZ \rightarrow l^+l^-l^+l^-$	1.02

- **Triple gauge couplings**

	$\mathscr{L}$ (fb^{-1})
$H \rightarrow \gamma\gamma$	1.08
$H \rightarrow \tau\tau$	1.06
$W/Z + (H \rightarrow bb)$	1.04
$H \rightarrow WW \rightarrow l^+\nu\, l^-\nu$	1.7
$H \rightarrow WW \rightarrow l\nu qq$	1.04
$H \rightarrow ZZ \rightarrow l^+l^-\, qq$	1.04
$H \rightarrow ZZ \rightarrow l^+l^-\, \nu\nu$	1.04
$H \rightarrow ZZ \rightarrow l^+l^-\, l^+l^-$	2.0 - 2.3

ATLAS Data Taking in 2011



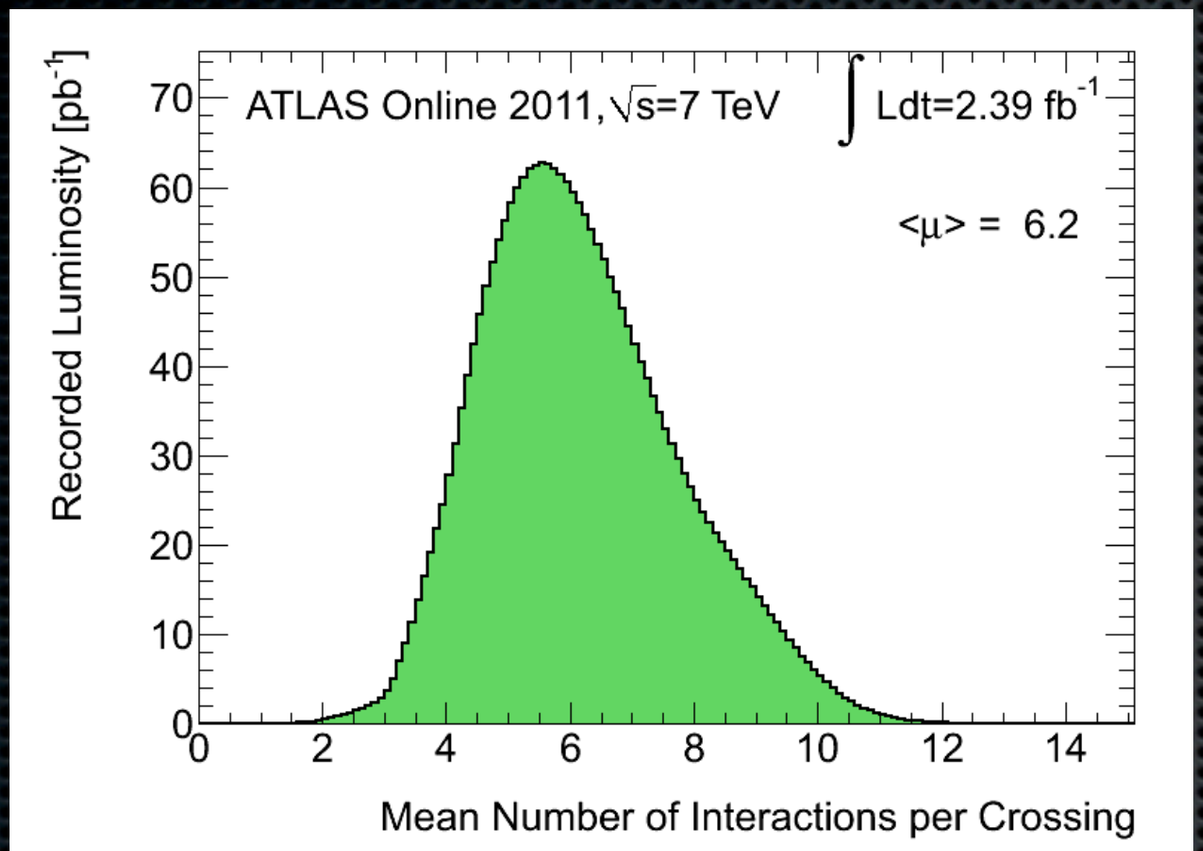


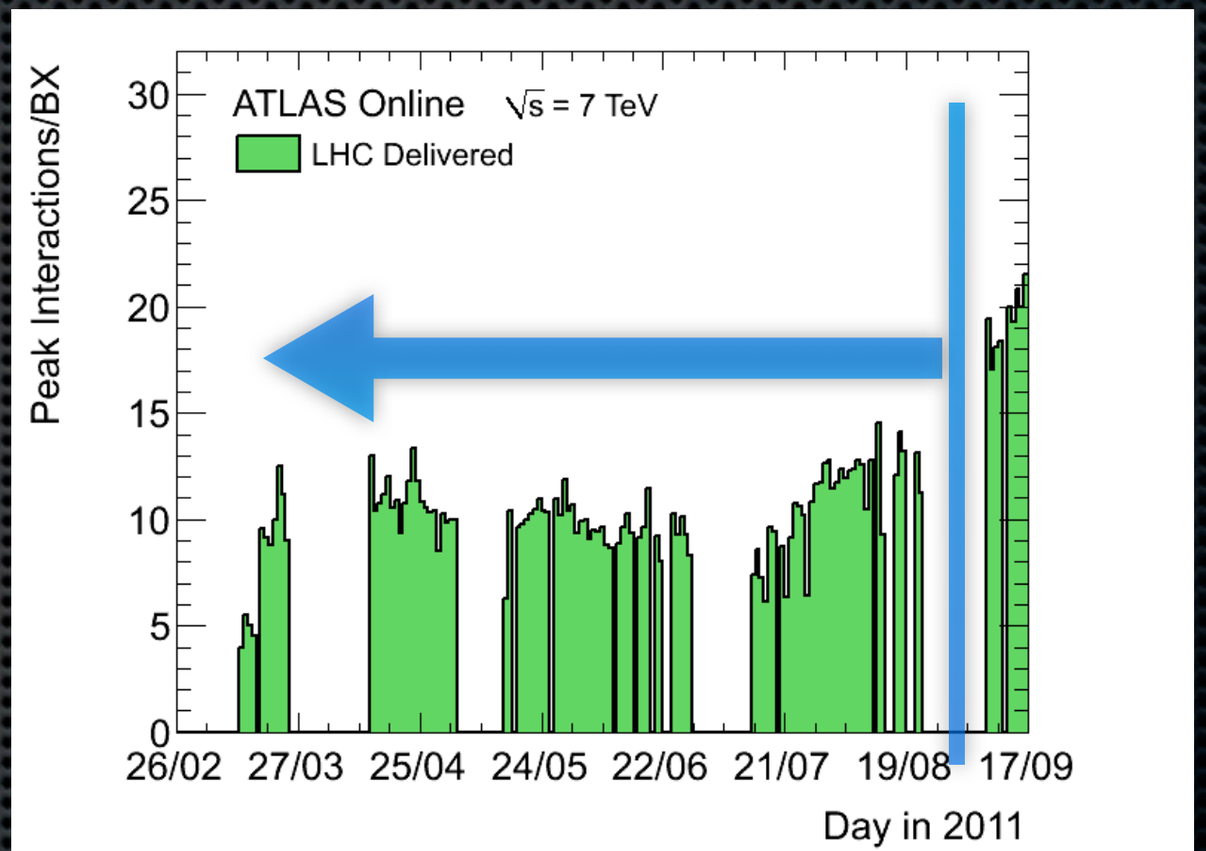
Data taking efficiency: ~ 94%

Good quality data delivered by the different sub-systems at 90-100%

High Luminosity: The Pileup Challenge

- **The new challenge with the 2011 data**
  - 50 ns bunch trains for most 2011 dataset
  - Significant in-time and out-of-time pileup





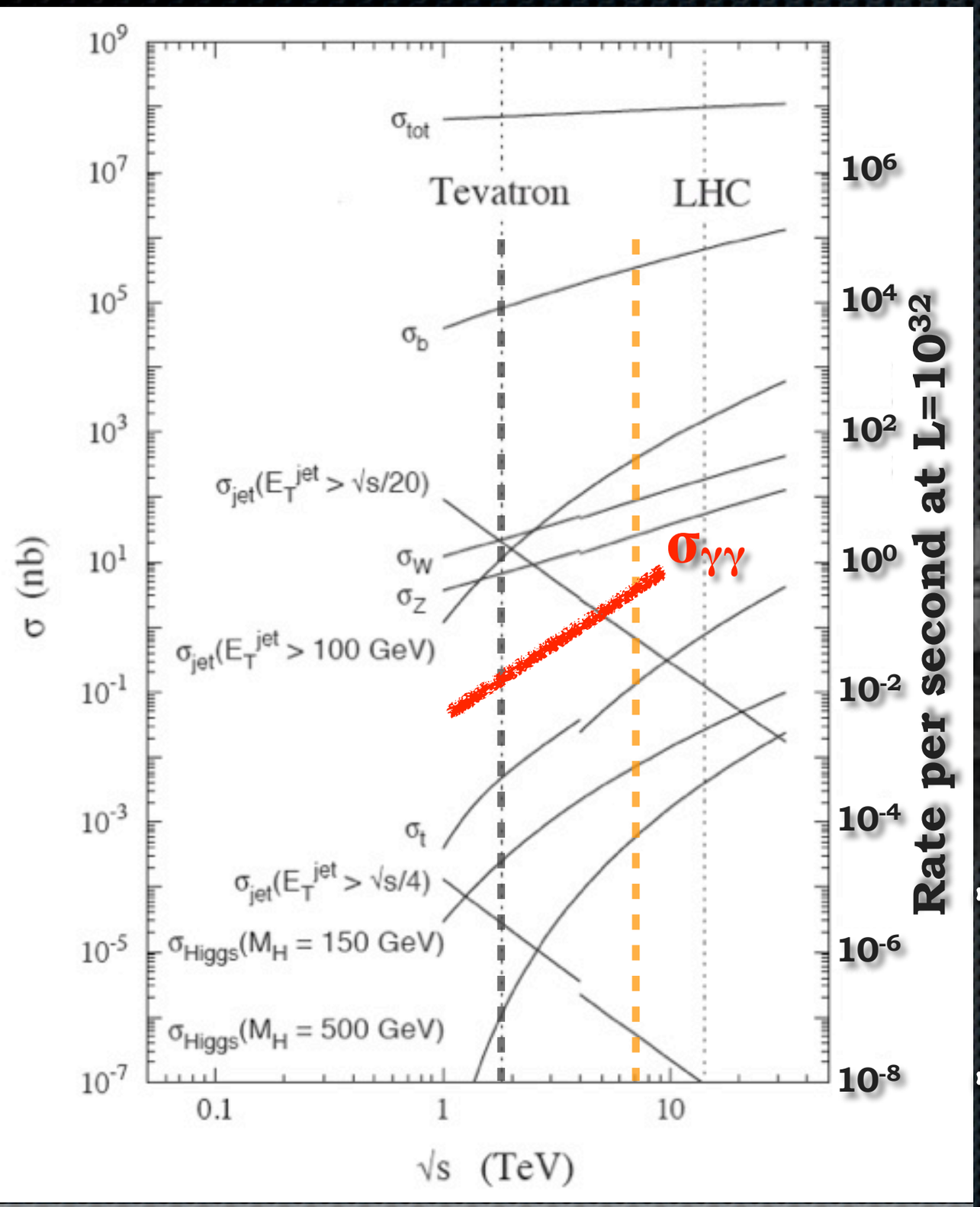
Luminosity weighted distribution

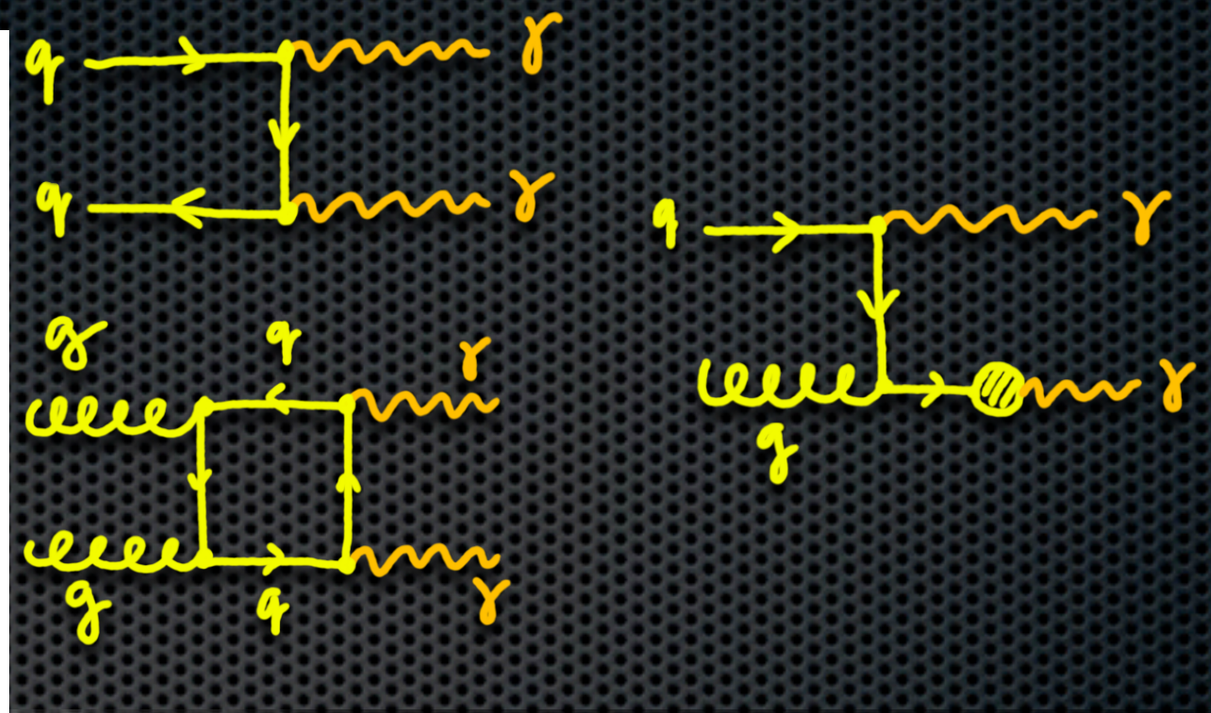
Significant progress made on the understanding of its effects:

- Primary vertex identification
- Missing energy resolution
- Jet energy scale
- Lepton isolation

Further work in progress

Standard Model Diboson Production in pp collisions at 7 TeV



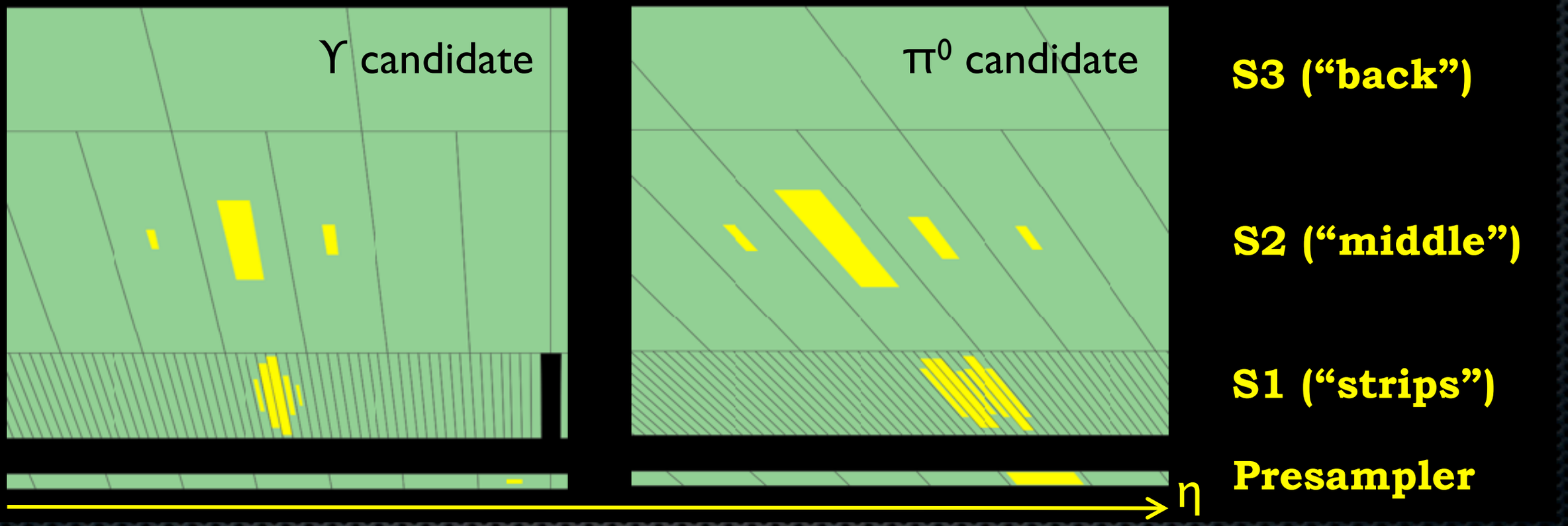


SM γγ Cross Section

- **Measure:**
  - *Isolated prompt* photons
- Test NLO pQCD predictions using measurements without jets
- **New Physics:**
  - Irreducible background to H → γγ
  - Extra dimension models

Photon Identification

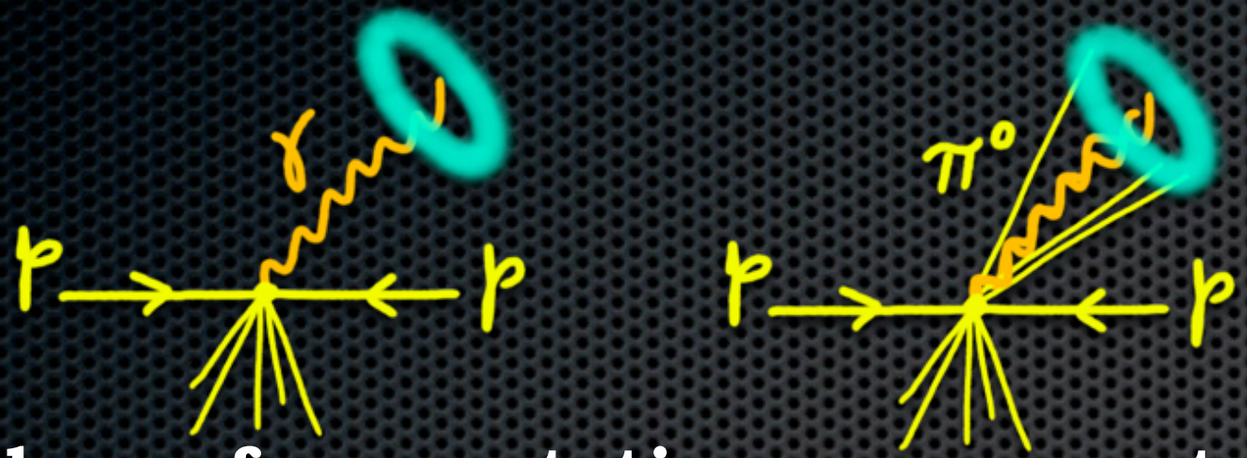
- **Photon identification based on calorimeter segmentation**



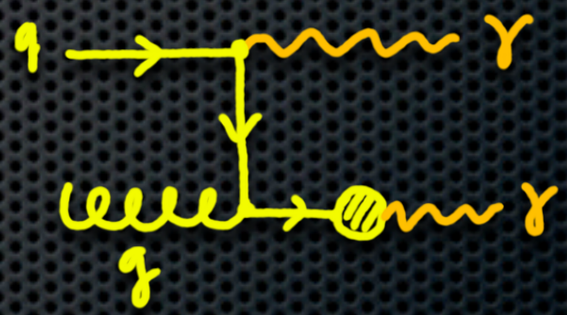
- **Photon reconstruction**
  - **Narrow energy cluster $|\eta|$**
  - **Small energy leakage into hadronic calorimeter**
  - **Cut on shower shape to discriminate γ from jets and π^0, η**

Photon Isolation

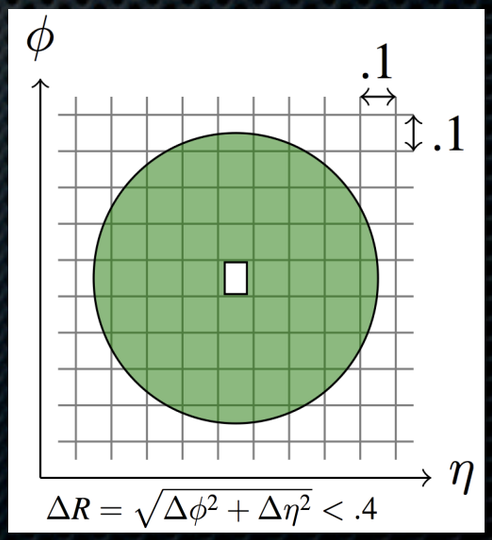
- **Isolation energy criterion to reduce jet background**



- **Reduces fragmentation component**
  - **~30% of inclusive γ cross section at 15 GeV**
  - **<10% above 35 GeV**



- **Isolation variable:**
  - **Sum of transverse energy in ΔR cone around γ**
  - **Exclude energy from central core**

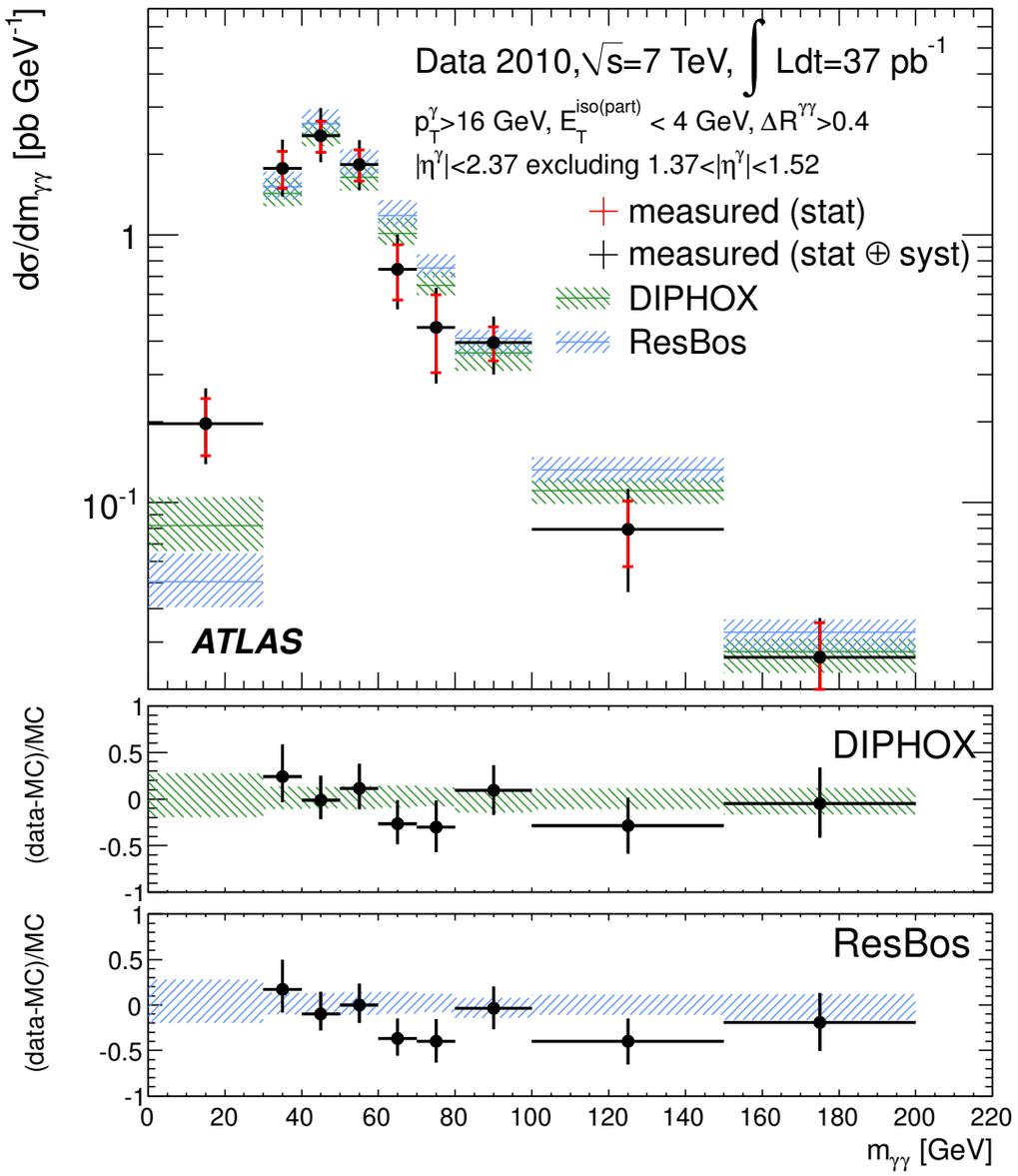


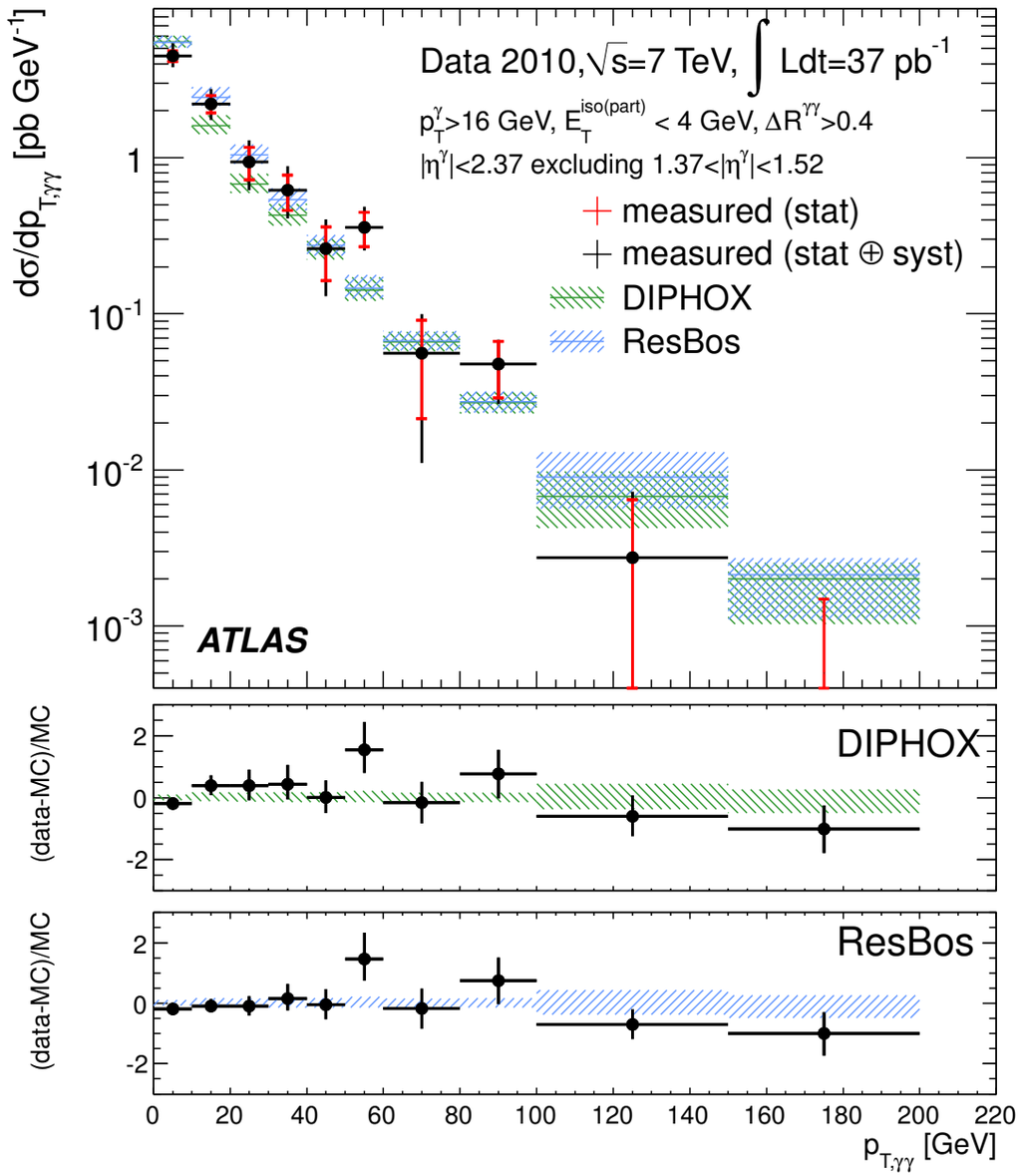
- **Corrections event-by-event**
  - **Remove energy leakage from γ into isolation cone**
  - **Remove energy from pileup and underlying event**

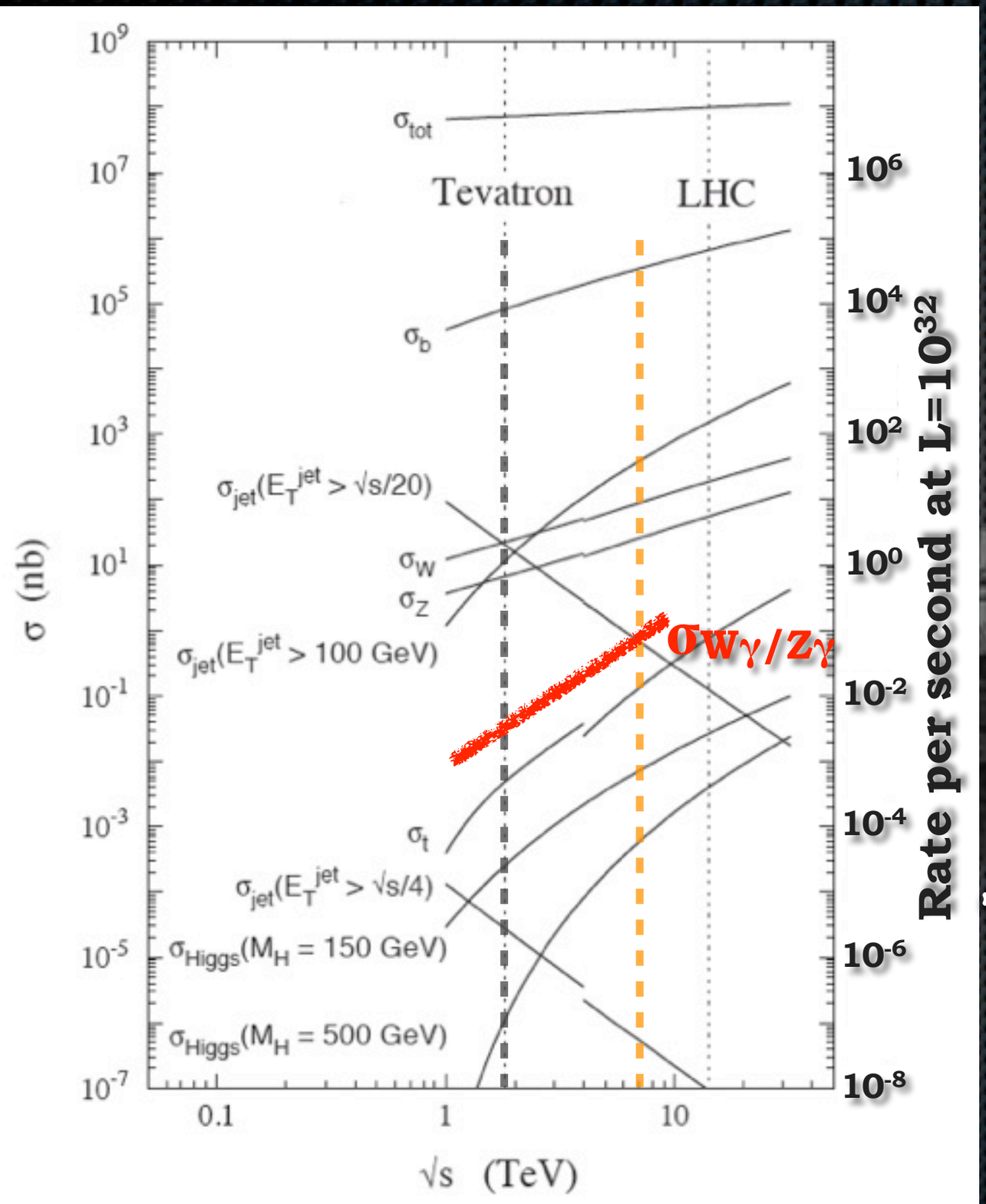
Isolated Diphoton Production Cross Section

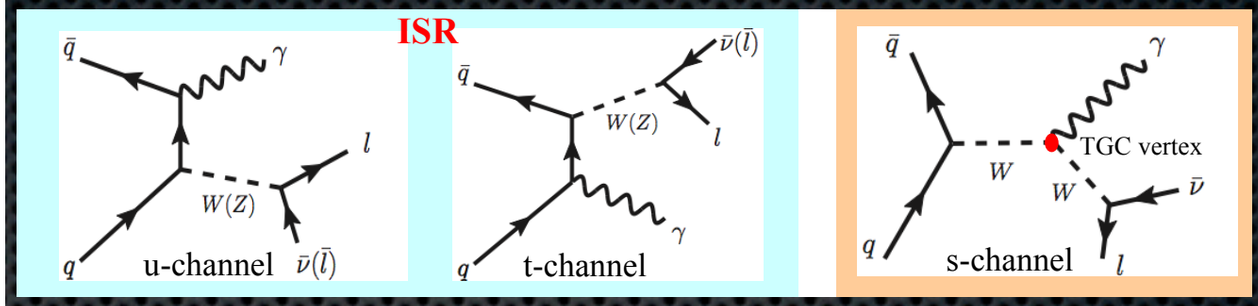
Two photons:

- $E_T^{\gamma} > 16$ GeV
- $\Delta R_{\gamma\gamma} > 0.4$
- $E_T^{iso} < 3$ GeV









Wγ/Zγ Cross Section

- **Test Triple Gauge Couplings of Electroweak theory**
  - Measure WWγ vertex in s-channel
  - Probe existence of ZZγ and Zγγ TGC
    - Forbidden in SM at tree level
- **Background for new physics**
  - Less problematic than other

Wγ/Zγ: Event Selection

Wγ

One lepton: $p_T > 20$ GeV

$|\eta_e| < 2.47$; $|\eta_\mu| < 2.4$

$E_T^{miss} > 25$ GeV

$M_T(l,\nu) > 40$ GeV

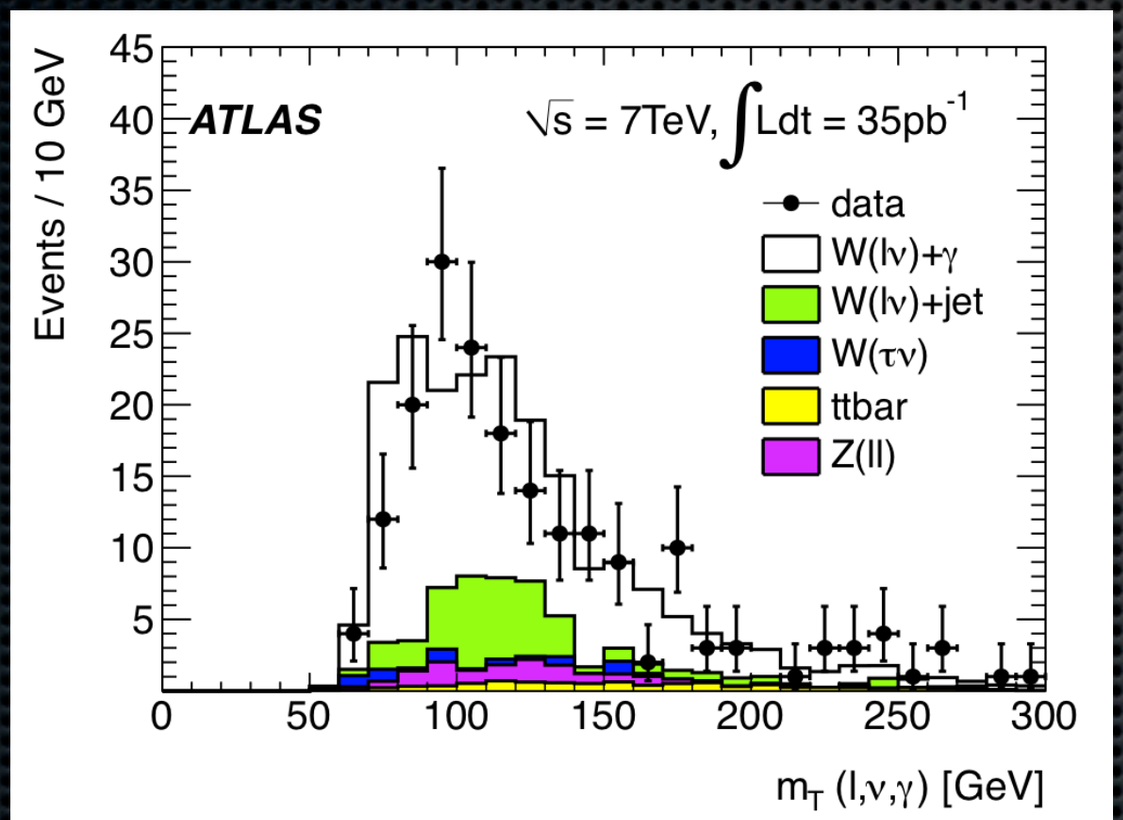
Zγ

Two OS lepton: $p_T > 20$ GeV

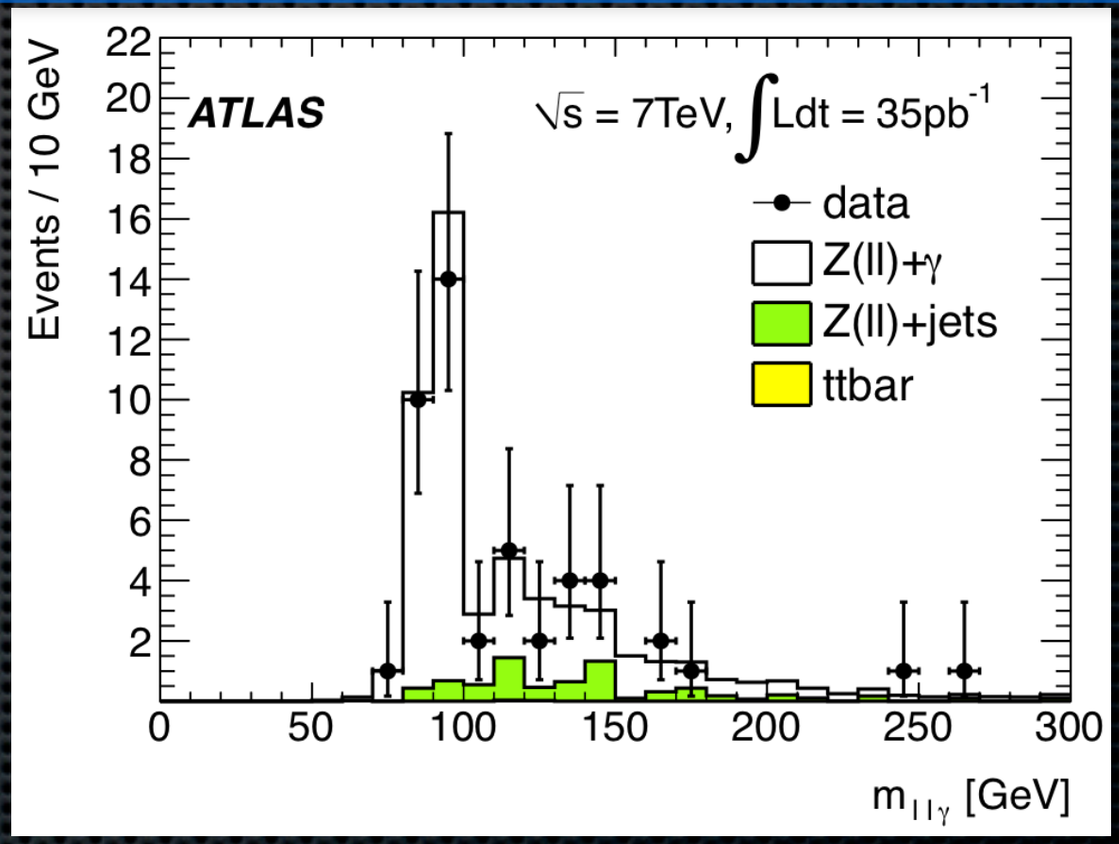
$|\eta_e| < 2.47$; $|\eta_\mu| < 2.4$

$M(l^+l^-) > 40$ GeV

Photon: $E_T^\gamma > 15$ GeV ; $\Delta R_{l\gamma} > 0.7$; $E_T^{iso} < 5$ GeV



	$N_{observed}$	N_{bkg}
Wγ	192	56

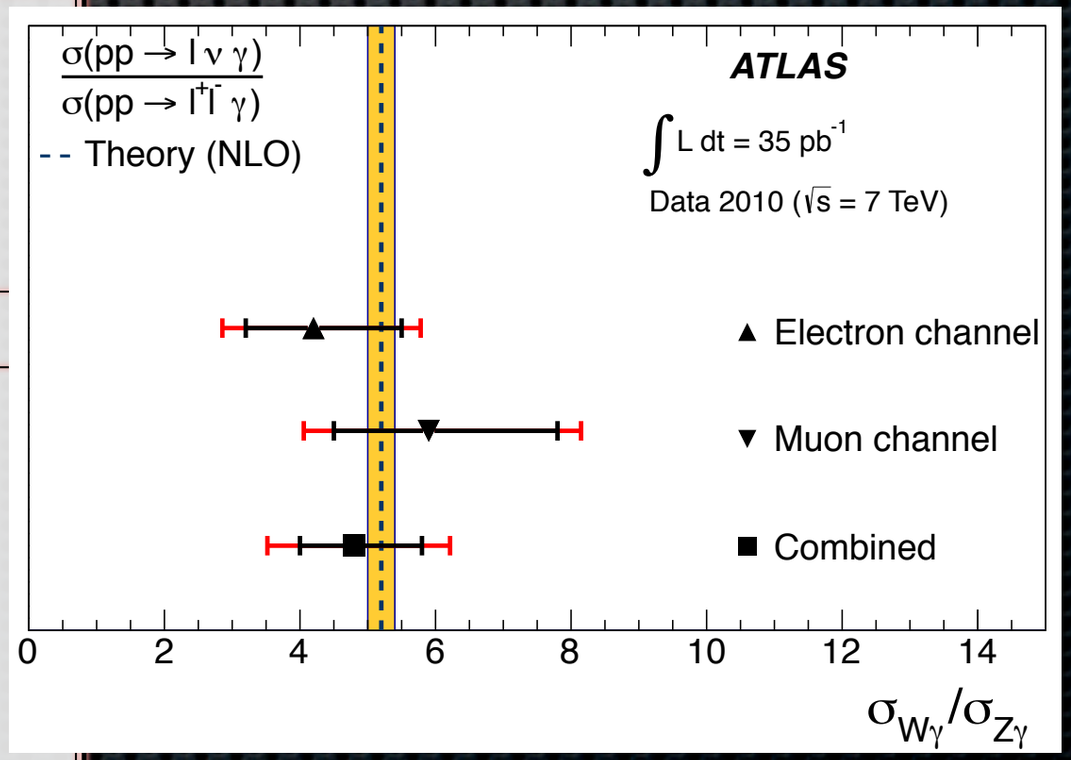


	$N_{observed}$	N_{bkg}
Zγ	48	7

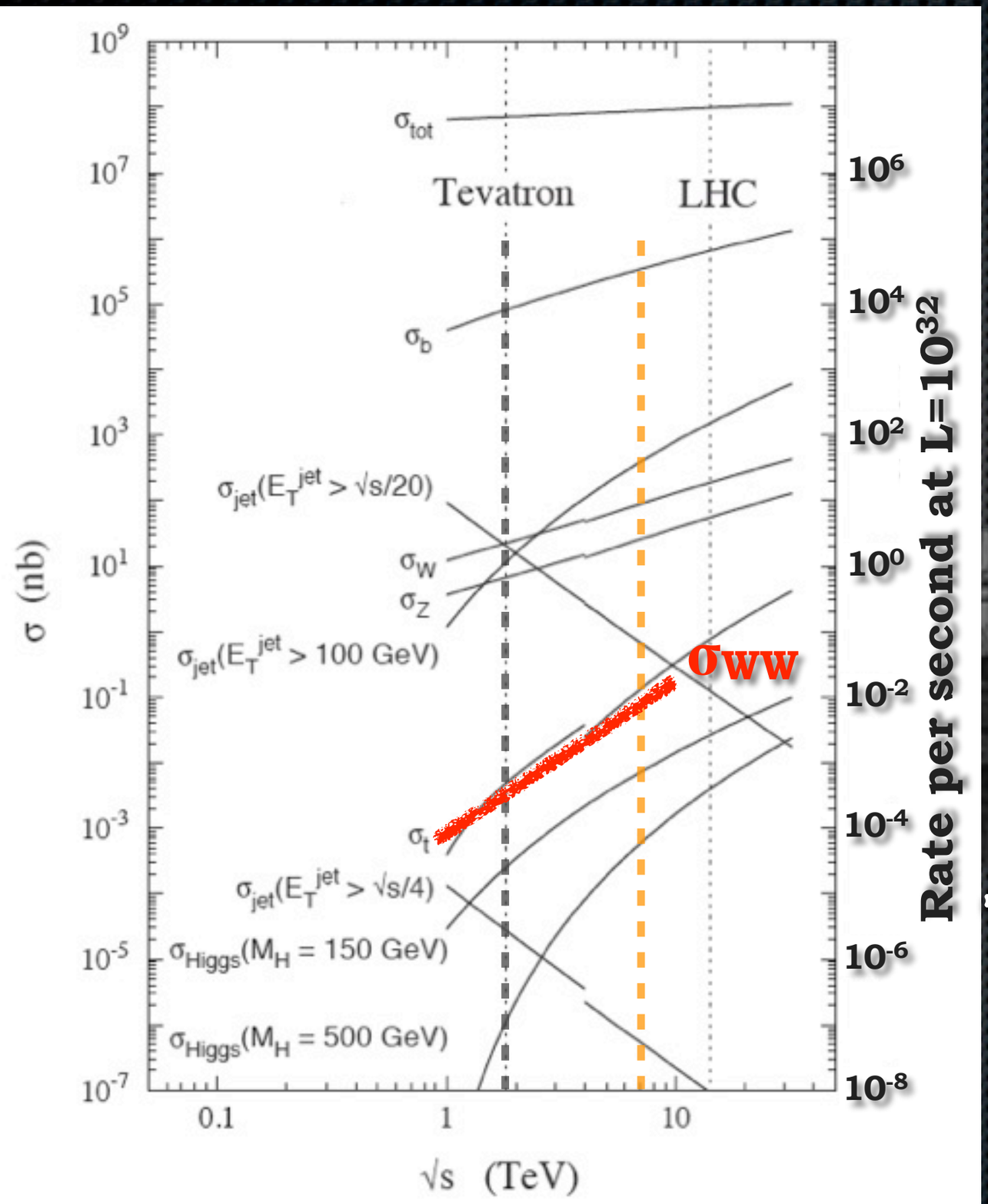
Wγ/Zγ: Results

- **Dominant uncertainties:**
  - **Photon reconstruction/ID efficiency: ~10%**
  - **Electron reconstruction/ID: ~ 4.5%**
  - **Electromagnetic scale and resolution: ~3-4.5%**

	Experimental measurement	SM prediction
	σ^{fid}[pb]	σ^{fid}[pb]
$pp \to e^{\pm}\nu\gamma$	$5.4 \pm 0.7 \pm 0.9 \pm 0.2$	4.7 ± 0.3
$pp \to \mu^{\pm}\nu\gamma$	$4.4 \pm 0.6 \pm 0.7 \pm 0.2$	4.9 ± 0.3
$pp \to e^{+}e^{-}\gamma$	$2.2 \pm 0.6 \pm 0.5 \pm 0.1$	1.5 ± 0.1
$pp \to \mu^{+}\mu^{-}\gamma$	$1.4 \pm 0.3 \pm 0.3 \pm 0.1$	1.7 ± 0.1
	σ[pb]	σ[pb]
$pp \to e^{\pm}\nu\gamma$	$41.1 \pm 5.7 \pm 7.1 \pm 1.4$	36.0 ± 2.3
$pp \to \mu^{\pm}\nu\gamma$	$33.0 \pm 4.6 \pm 5.5 \pm 1.1$	36.0 ± 2.3
$pp \to l^{\pm}\nu\gamma$	$36.0 \pm 3.6 \pm 6.2 \pm 1.2$	36.0 ± 2.3
$pp \to e^{+}e^{-}\gamma$	$9.9 \pm 2.7 \pm 2.3 \pm 0.3$	6.9 ± 0.5
$pp \to \mu^{+}\mu^{-}\gamma$	$5.6 \pm 1.4 \pm 1.2 \pm 0.2$	6.9 ± 0.5
$pp \to l^{+}l^{-}\gamma$	$6.5 \pm 1.2 \pm 1.7 \pm 0.2$	6.9 ± 0.5

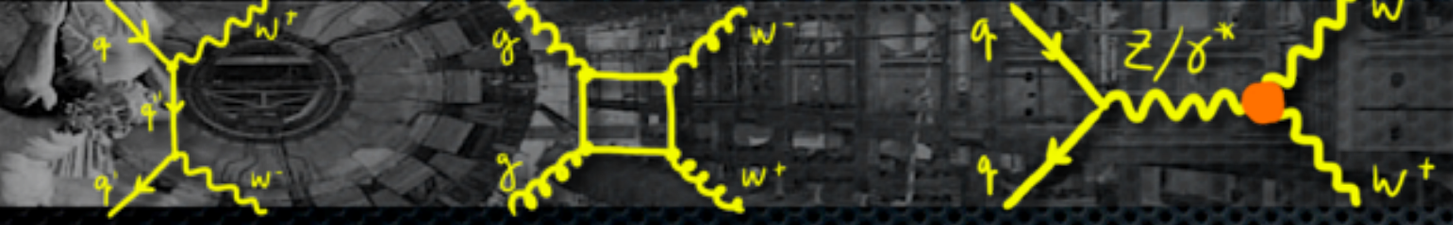


Fiducial cross section: phase space mimics selection requirements



WW Cross Section

- Fundamental test of Standard Model
  - Triple gauge couplings (TGC)
- Higgs hunting
  - Similar signature to H → WW
  - Background to Higgs

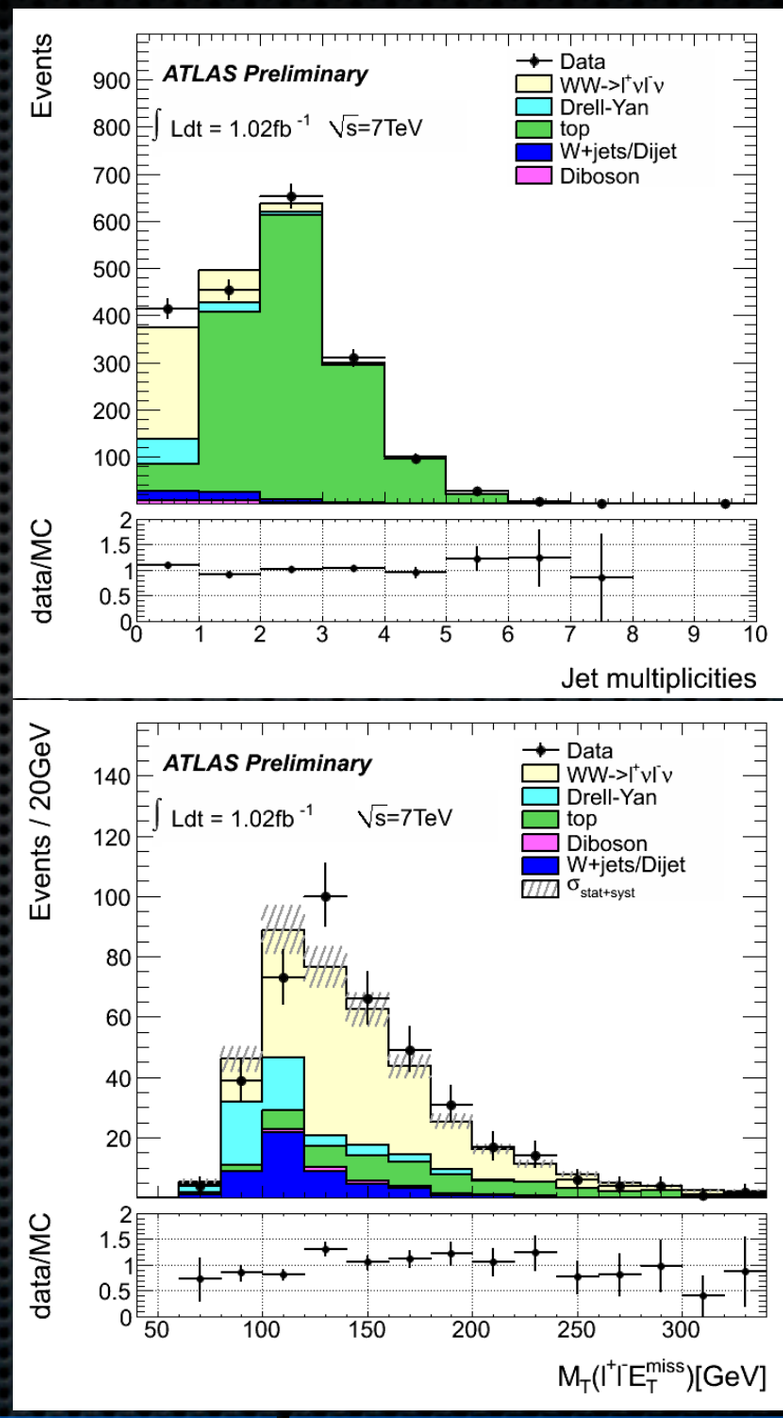


WW Production

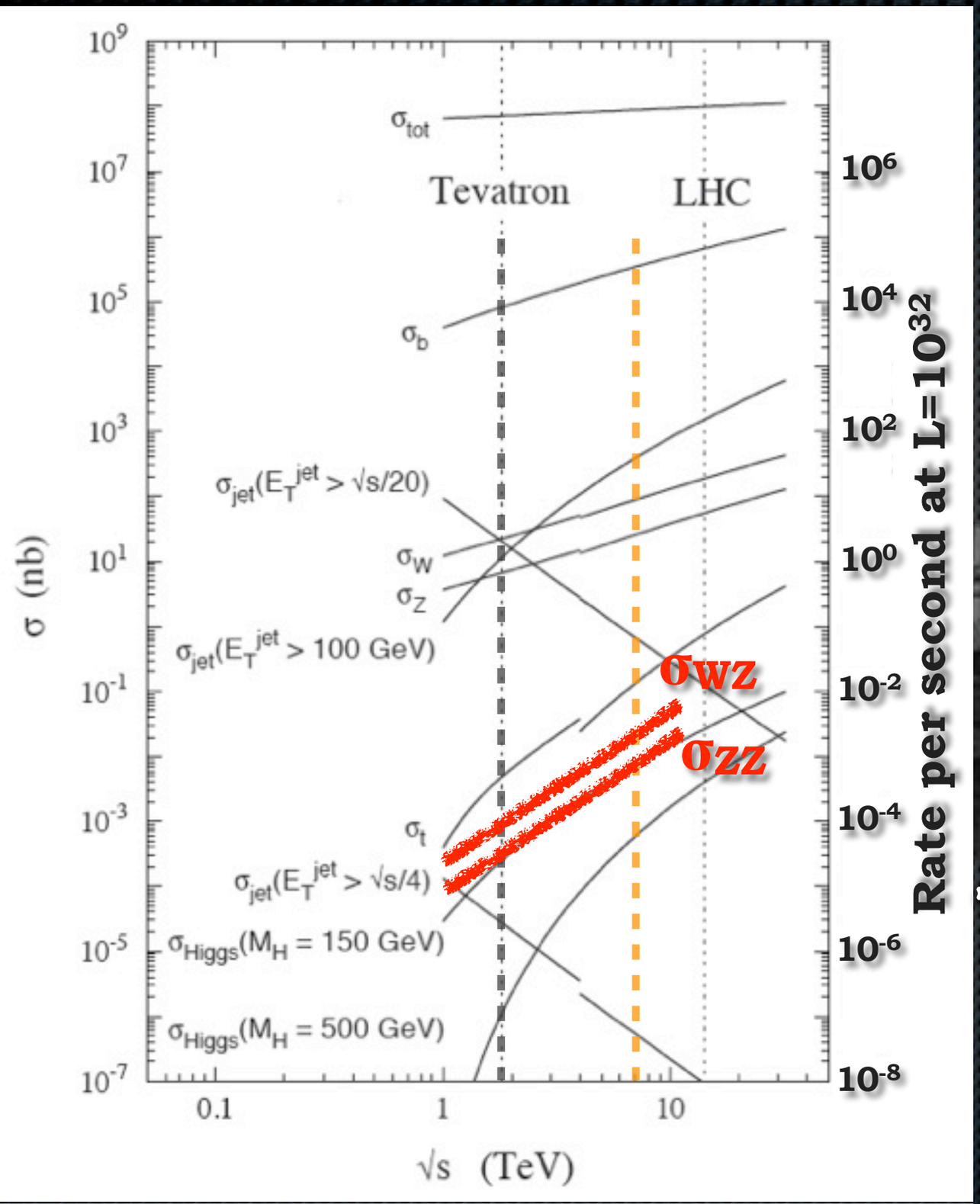
- **Event selection**
  - **Two high-p_T OS leptons**
  - **Z mass veto**
  - **Large E_T^{miss}**

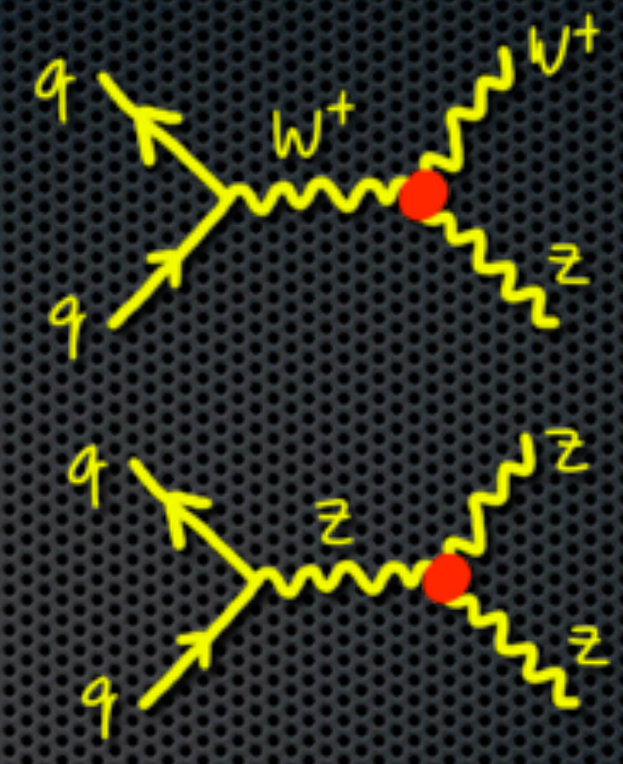
$$E_{\mathrm{T,\,Rel}}^{\mathrm{miss}} = \begin{cases} E_{\mathrm{T}}^{\mathrm{miss}} \times \sin\left(\Delta\phi_{\ell,j}\right) & \text{if } \Delta\phi < \pi/2 \\ E_{\mathrm{T}}^{\mathrm{miss}} & \text{if } \Delta\phi \geq \pi/2 \end{cases}$$

  - **Jet veto**
- **Backgrounds: Top, Drell-Yan and W+jets (~40%)**
  - **Drell-Yan: Z mass veto + missing E_T requirement**
  - **Top and W+jets: apply jet veto**



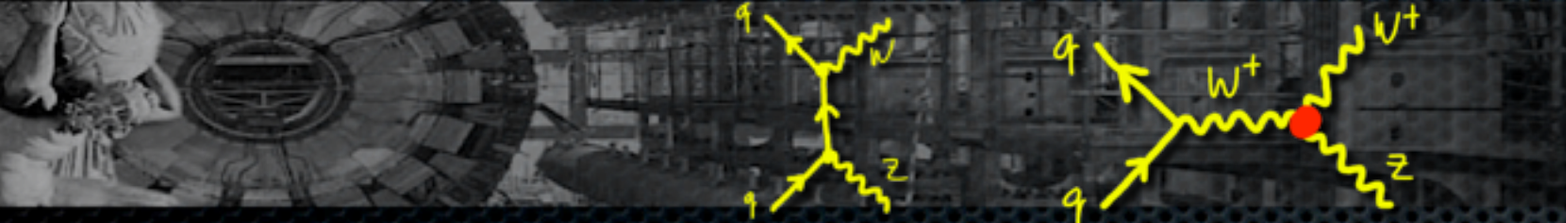
	$N_{observed}$	N_{bkg}	$\sigma_{measured}$ (pb)	σ_{NLO} (pb)
WW	414	170 ± 28	48.2 ± 4.0 ± 6.4 ± 1.8	46 ± 3





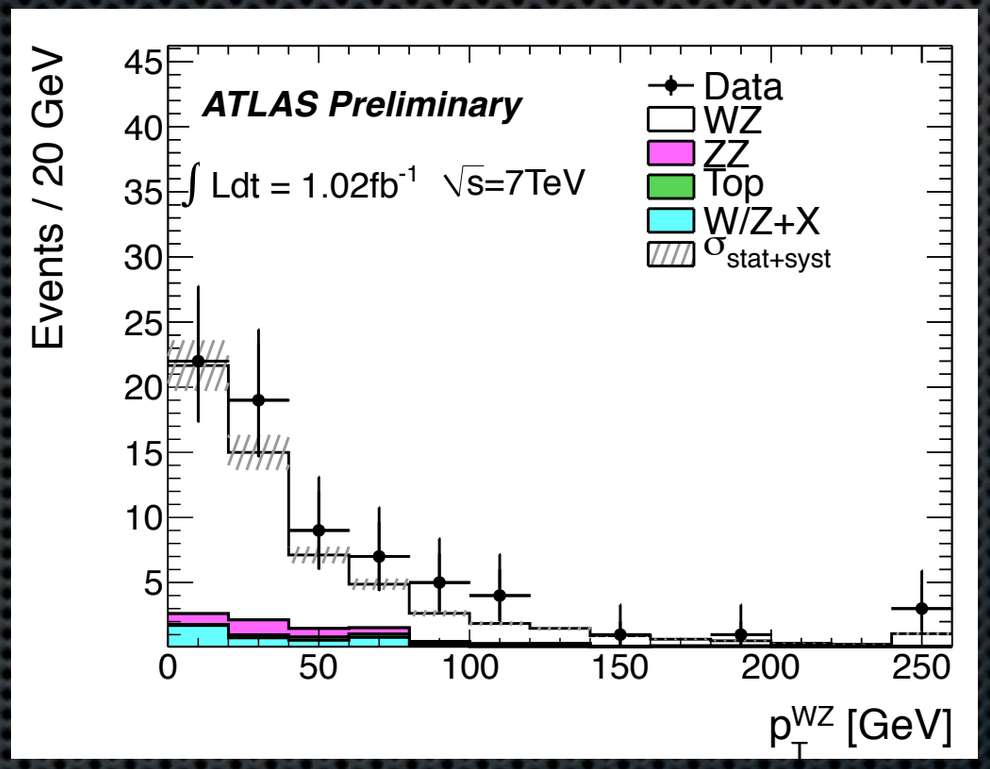
WZ and ZZ Cross Sections

- Fundamental test of Standard Model
  - Triple gauge couplings (TGC)
  - Probe for new physics
    - Resonances with diboson final states
- Higgs hunting
  - Similar signatures $H \rightarrow ZZ$
  - SM ZZ background to Higgs



WZ Production

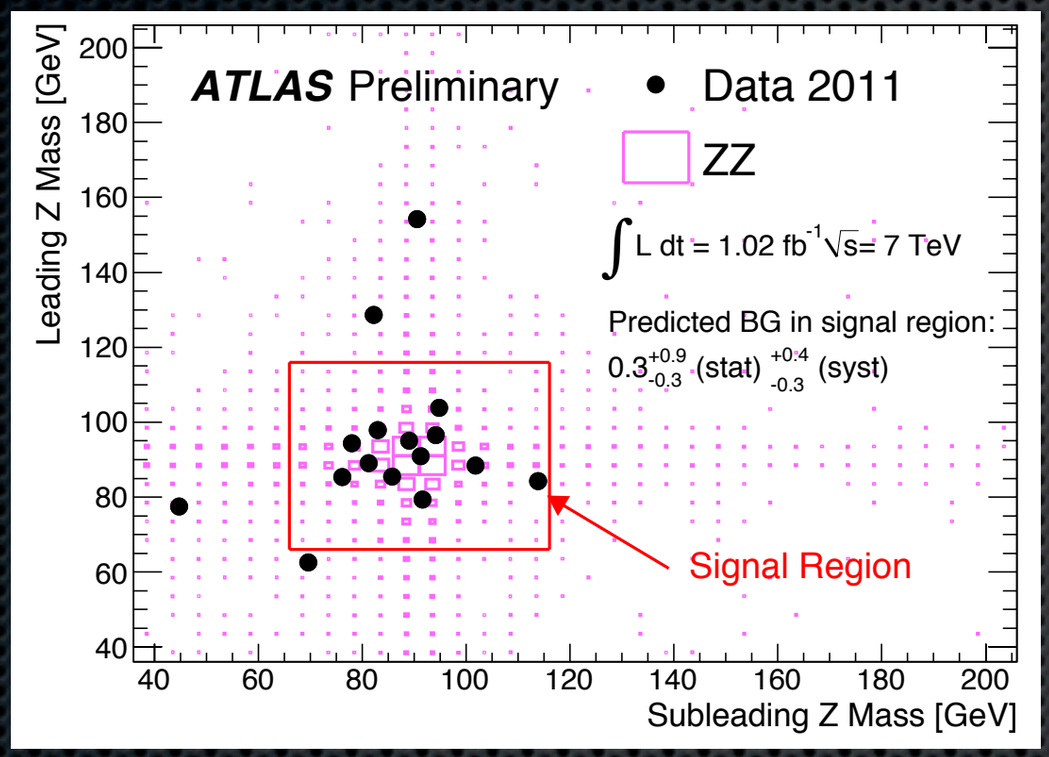
- **Cut based analysis**
  - **Select one Z events, then:**
    - **One lepton + missing E_T**
  - **Main backgrounds: Z+jets, ZZ, Top and W/Z+γ (15%)**

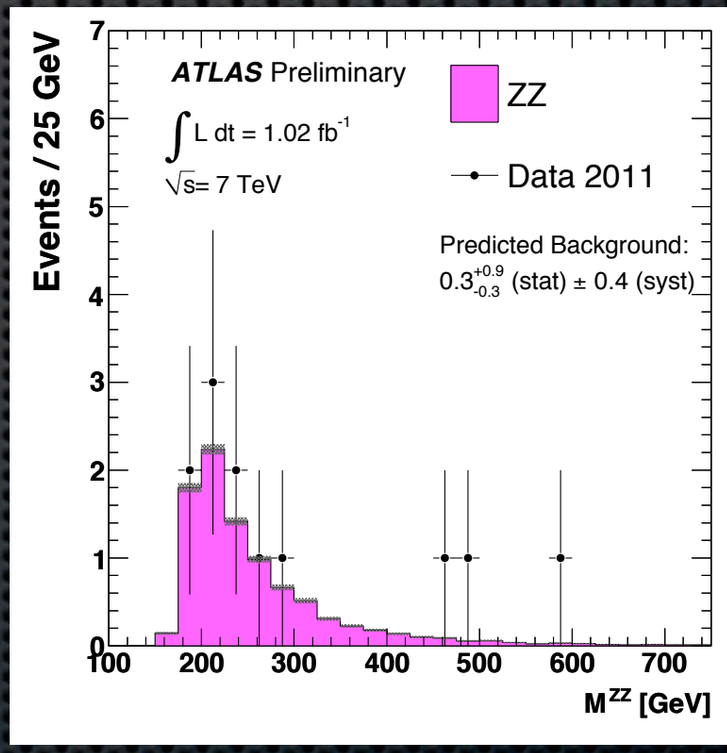


	$N_{observed}$	N_{bkg}	$\sigma_{measured}$ (pb)	σ_{NLO} (pb)
WZ	71	$10.5^{+3.0}_{-2.2}$	$21.1^{+3.1}_{-2.8} \pm 1.2^{+0.9}_{-0.8}$	$17.2^{+1.2}_{-0.8}$

ZZ Production

- **Cut based analysis**
  - **Very clean signature**
    - **Electron and muon selection relaxed relative to inclusive Z**
  - **Main backgrounds: Z+jets, Top and Zbb (3%)**





	$N_{observed}$	N_{bkg}	$\sigma_{measured}$ (pb)	σ_{NLO} (pb)
ZZ	12	$0.3^{+1.0}_{-0.4}$	$8.4\ ^{+2.7}_{-2.3}\ ^{+0.4}_{-0.7} \pm 0.3$	$6.5\ ^{+0.3}_{-0.2}$

Triple Gauge Couplings

Triple Gauge Couplings

- **Possible vertices using an effective Lagrangian**

ZZZ, ZZγ

$(f_4^Z, f_4^\gamma, f_5^Z, f_5^\gamma) = (0,0,0,0)_{SM}$

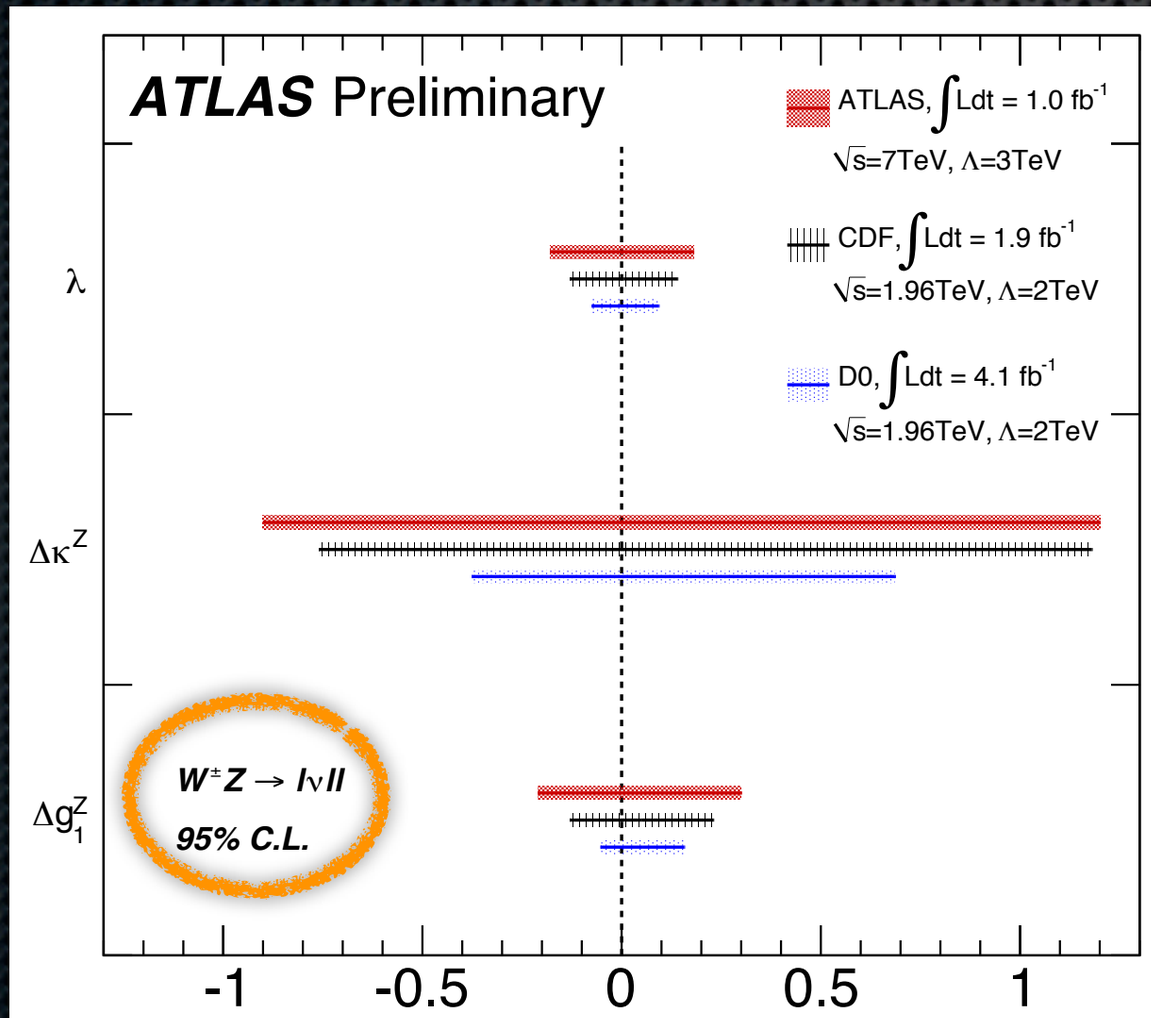
WWZ

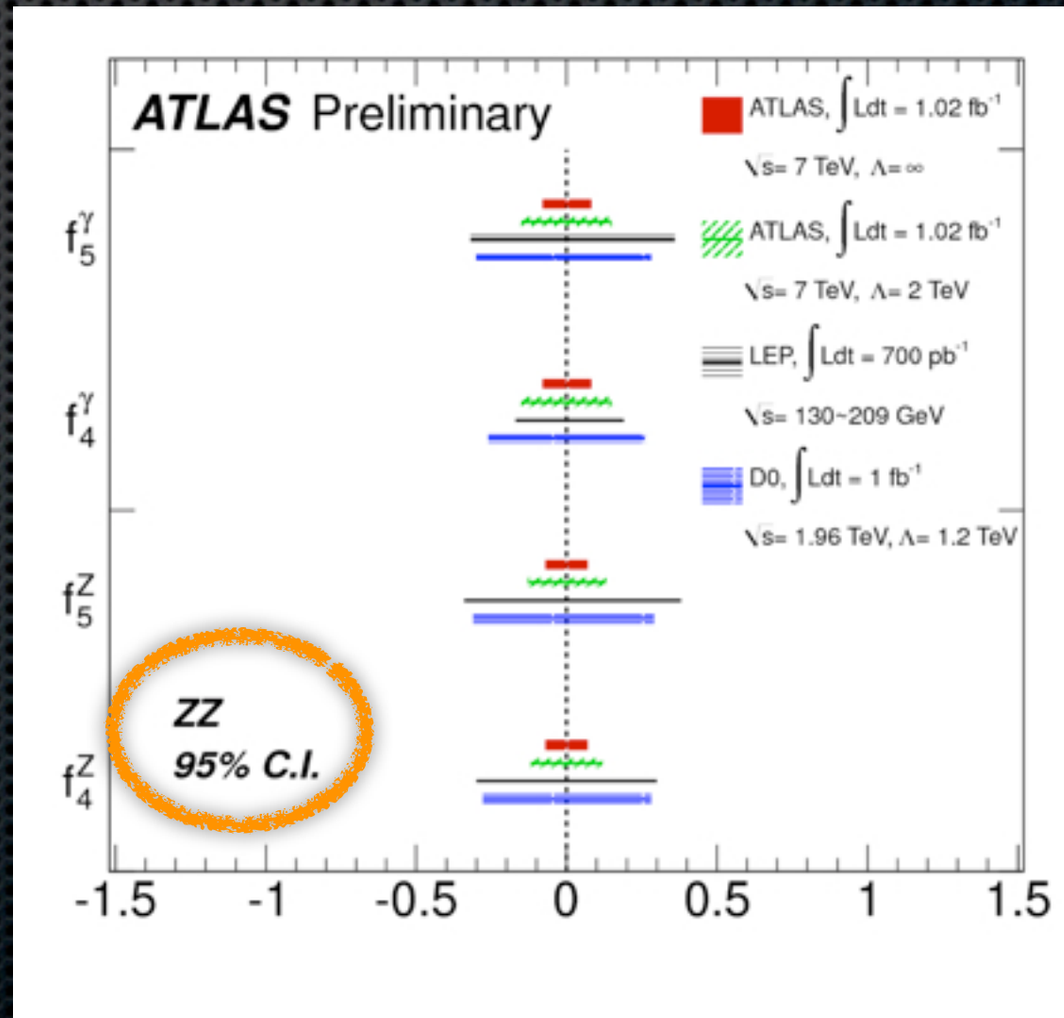
$(g_1^Z, k^Z, \lambda) = (1,1,0)_{SM}$

Scale dependent form-factors

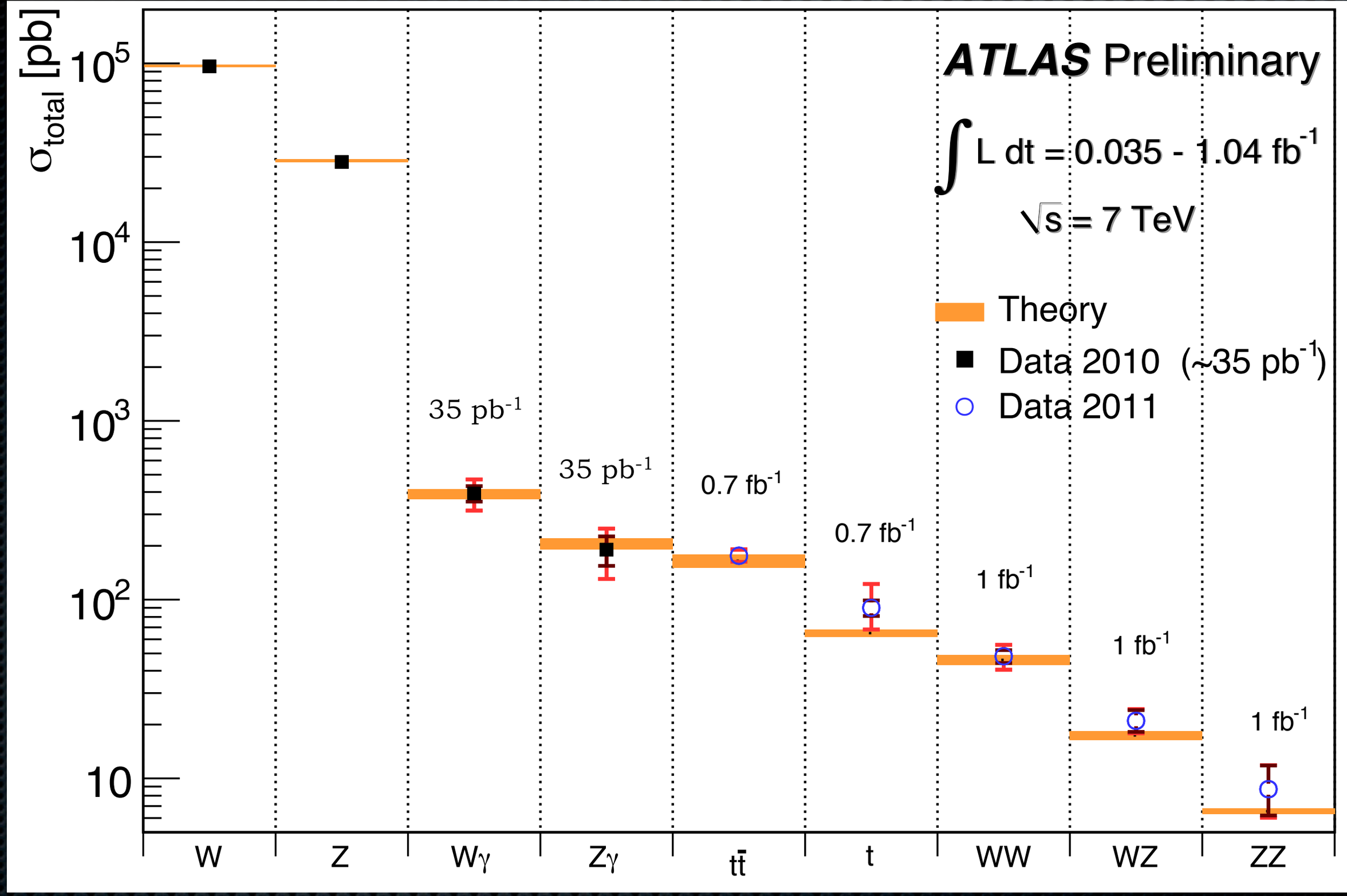
$$\alpha(\hat{s}) = \frac{\alpha_0}{(1+\hat{s}/\Lambda^2)^2}$$

with cutoff scale Λ

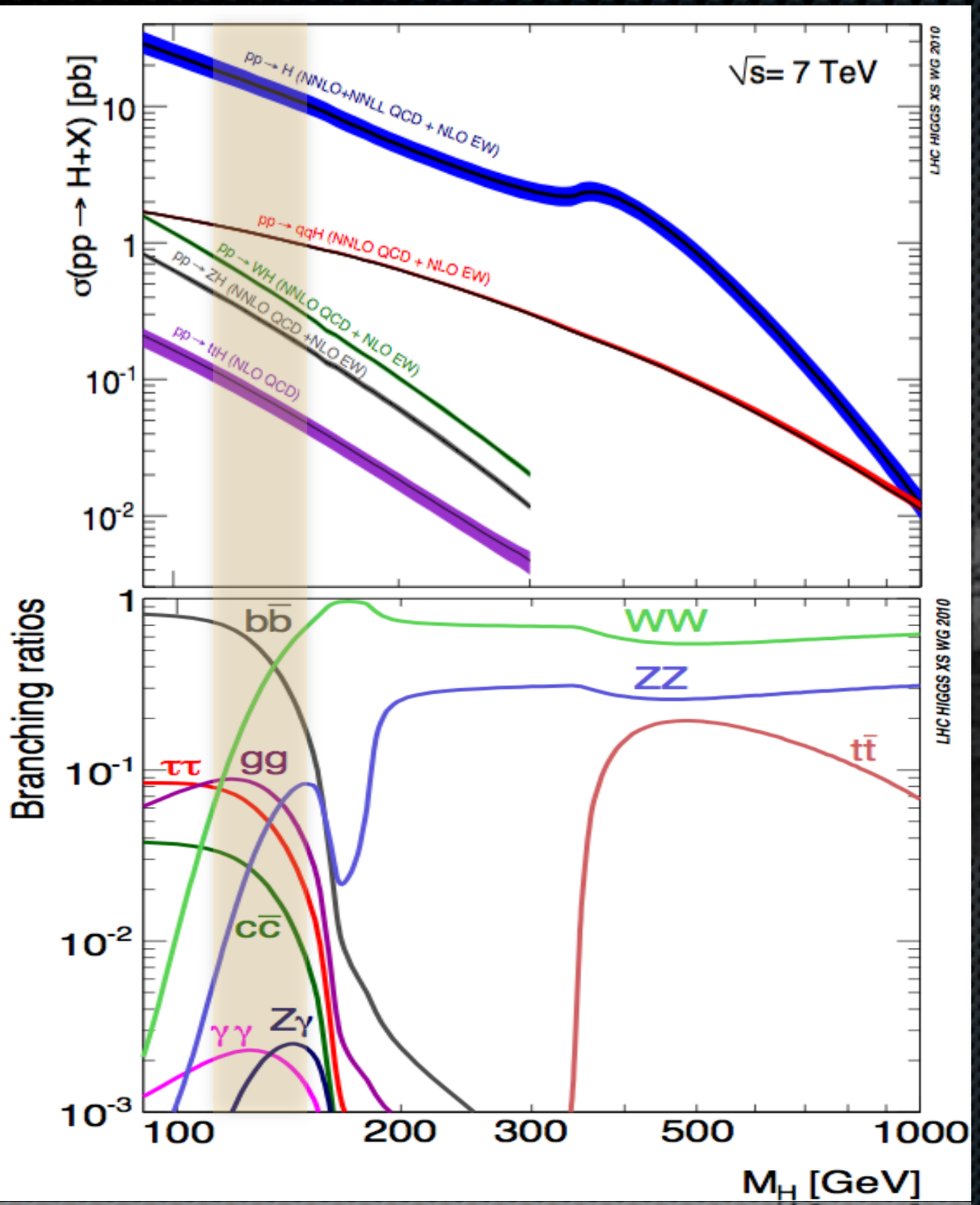


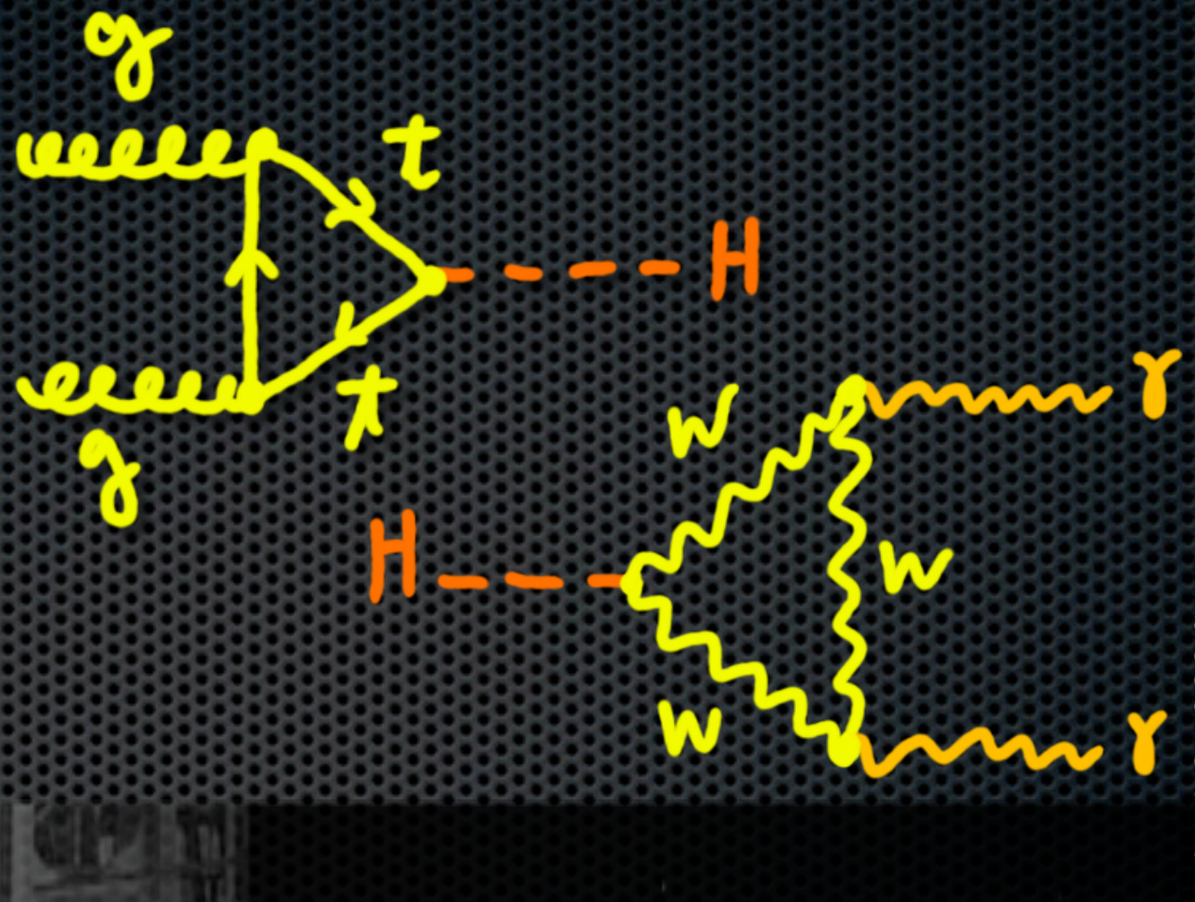


Diboson Cross Sections Measured by ATLAS



Search for the SM Higgs Boson





H → γγ

- The key channel for the low-mass Higgs
  - Small BR (~ 0.002)
  - But, clean signature
- SM γγ: irreducible background

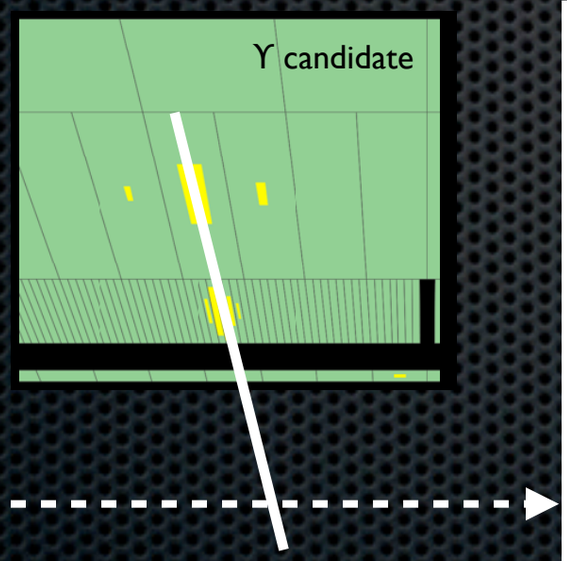
H → γγ: Selection and Mass Reconstruction

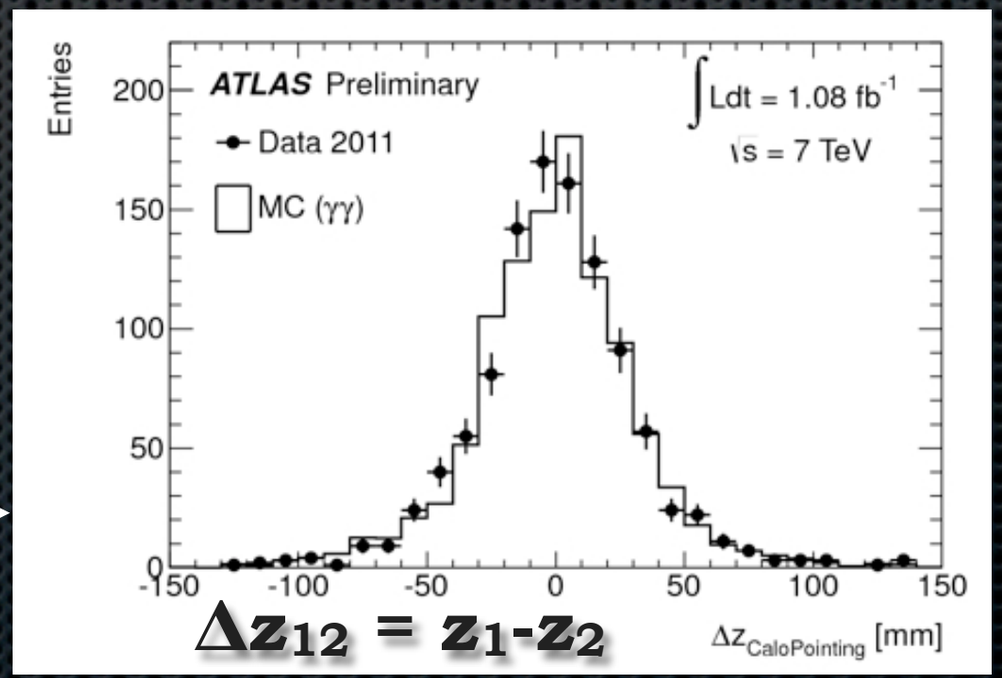
- **Two high-quality isolated high-pt photons**
  - p_{T1} > 40 GeV; p_{T2} > 25 GeV
  - Five event categories:
    - Converted/unconverted photons + η regions of calorimeter
    - Different invariant mass resolution and S/B

- **Mass reconstruction**
  - Energy resolution: Δp ~ 1.3 GeV
    - Energy scale calibration from Z → ee
  - Interaction point spread: RMS(z) ~ 5.5 cm

$$m^2 = 2p_1p_2(1-\cos\theta) \sim p_1p_2\theta^2$$

$$\Delta m/m = (1/\sqrt{2})\Delta p/p \oplus \Delta\theta/\theta$$





Vertex resolution from unconverted photons

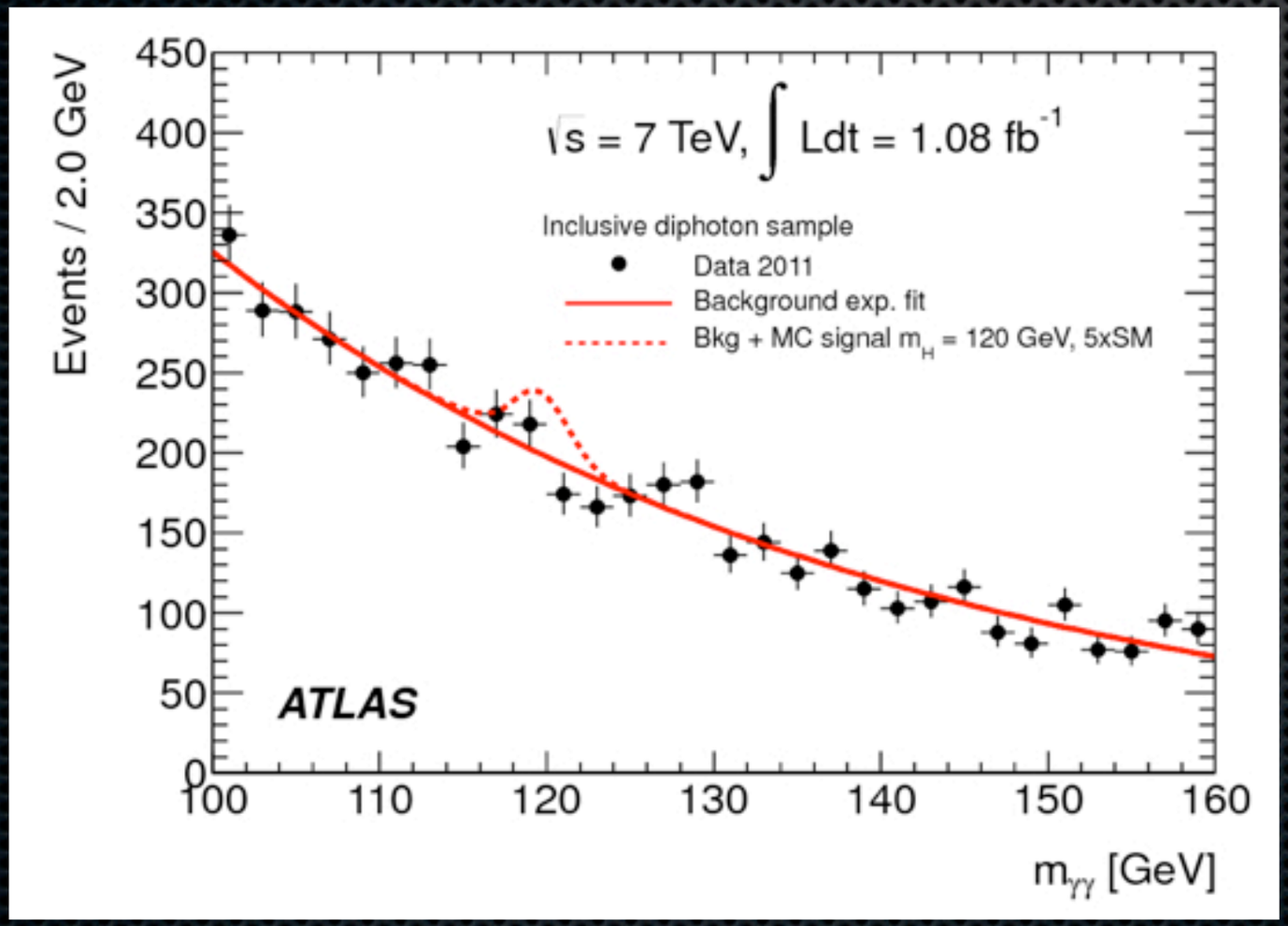
σ(z) ~ 1.6 cm

m_H = 120 GeV

σ (m)~1.7 GeV

H → γγ: Background and Results

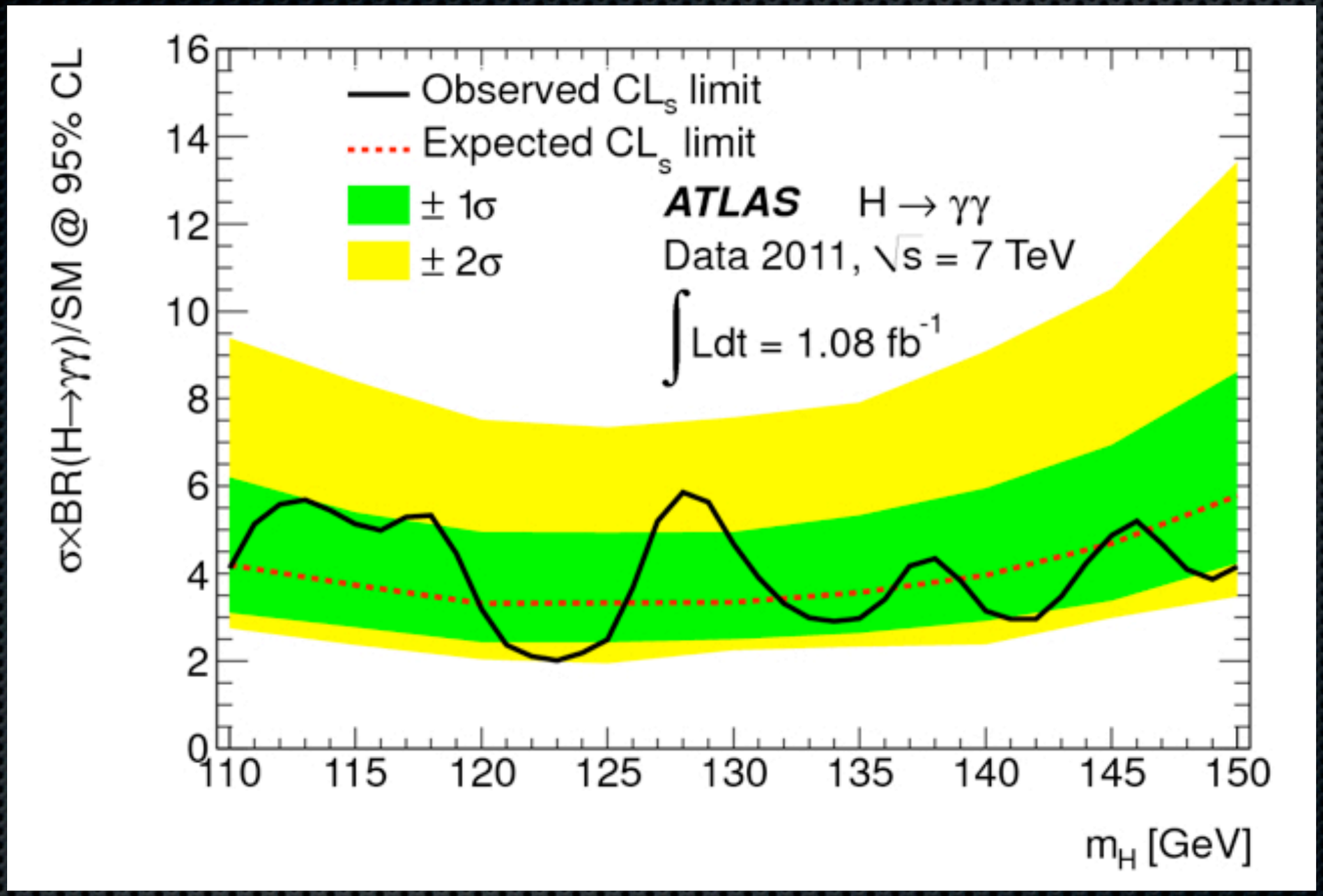
- **Measure the SM backgrounds using control samples**
  - **Consider photon isolation and identification criteria (loose vs tight) to extract:**
    - **γ-γ, γ-jet and jet-jet background components**



5063 events pass full selection with
100 GeV < mγγ < 150 GeV

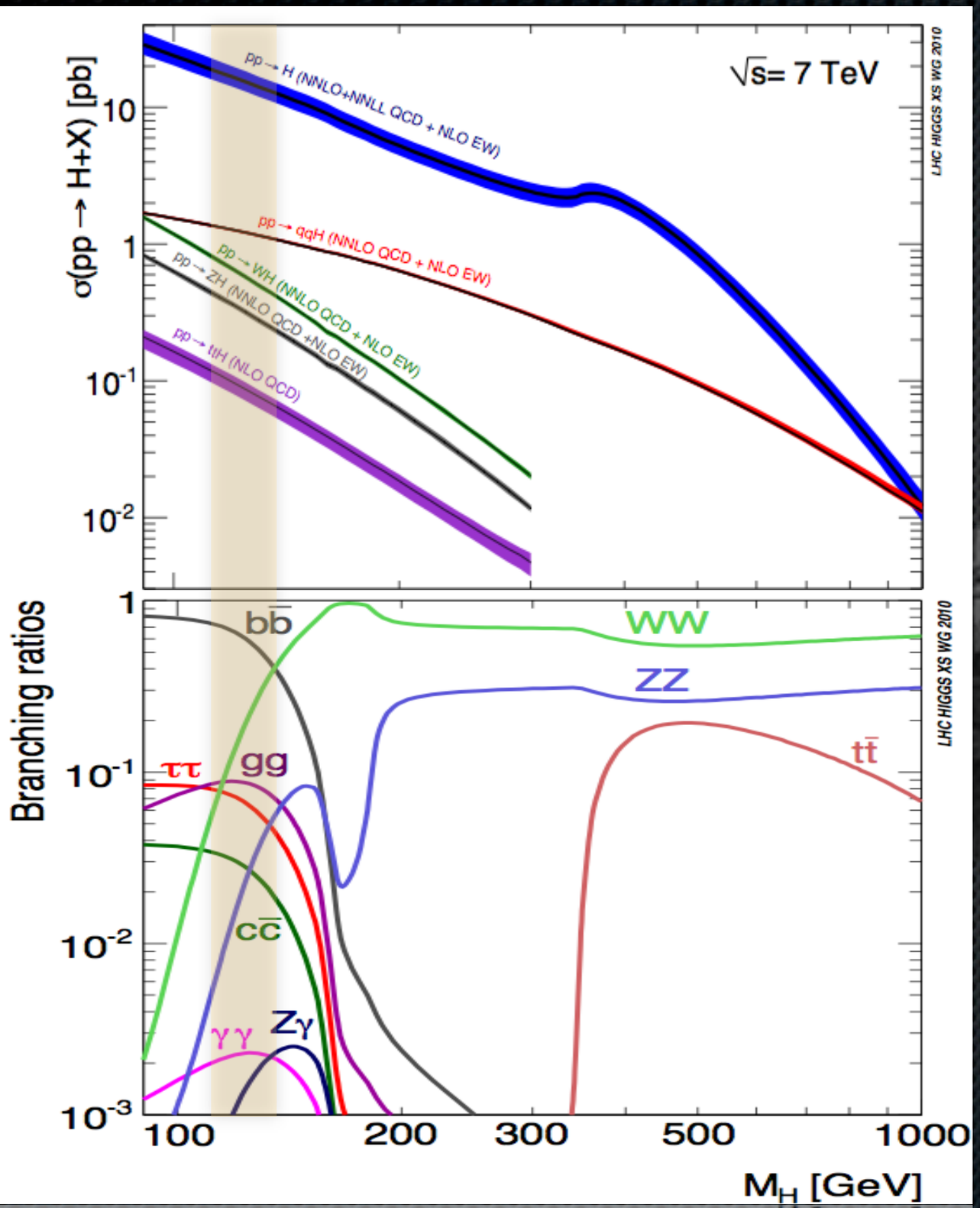
Maximum likelihood fit to exponential background and signal templates

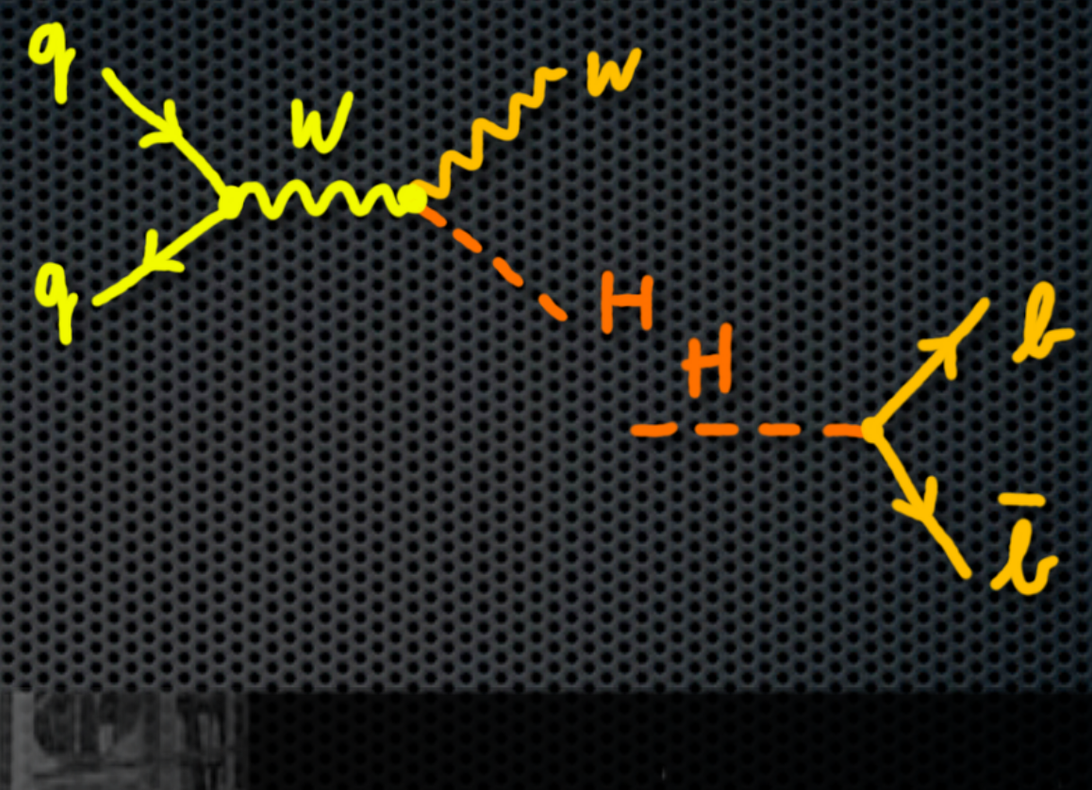
H → γγ: Limits



- **$110 < m_H < 150$ GeV**
  - **Expected upper limit: ~3.3-5.8 × σ_{SM}**
  - **Observed upper limit: 2 × σ_{SM} (mH =123 GeV)**

m_H < 130 GeV



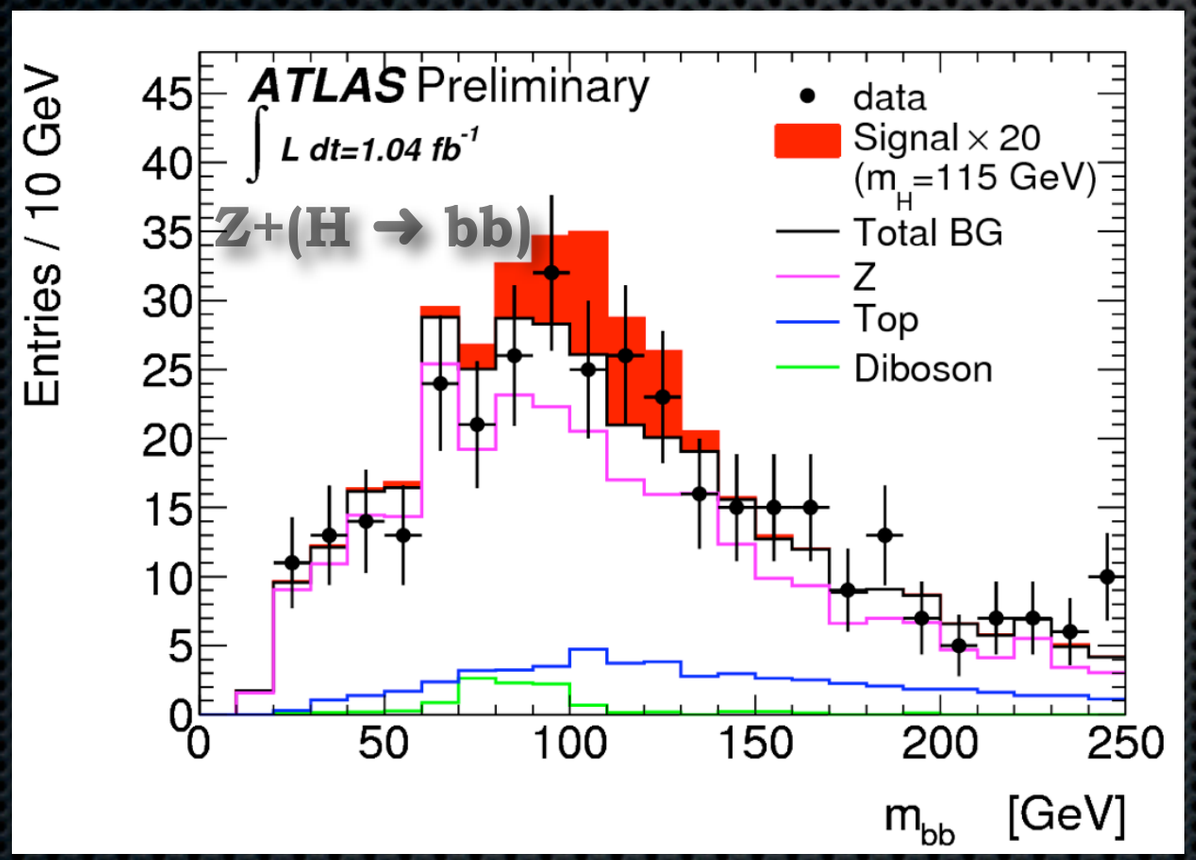


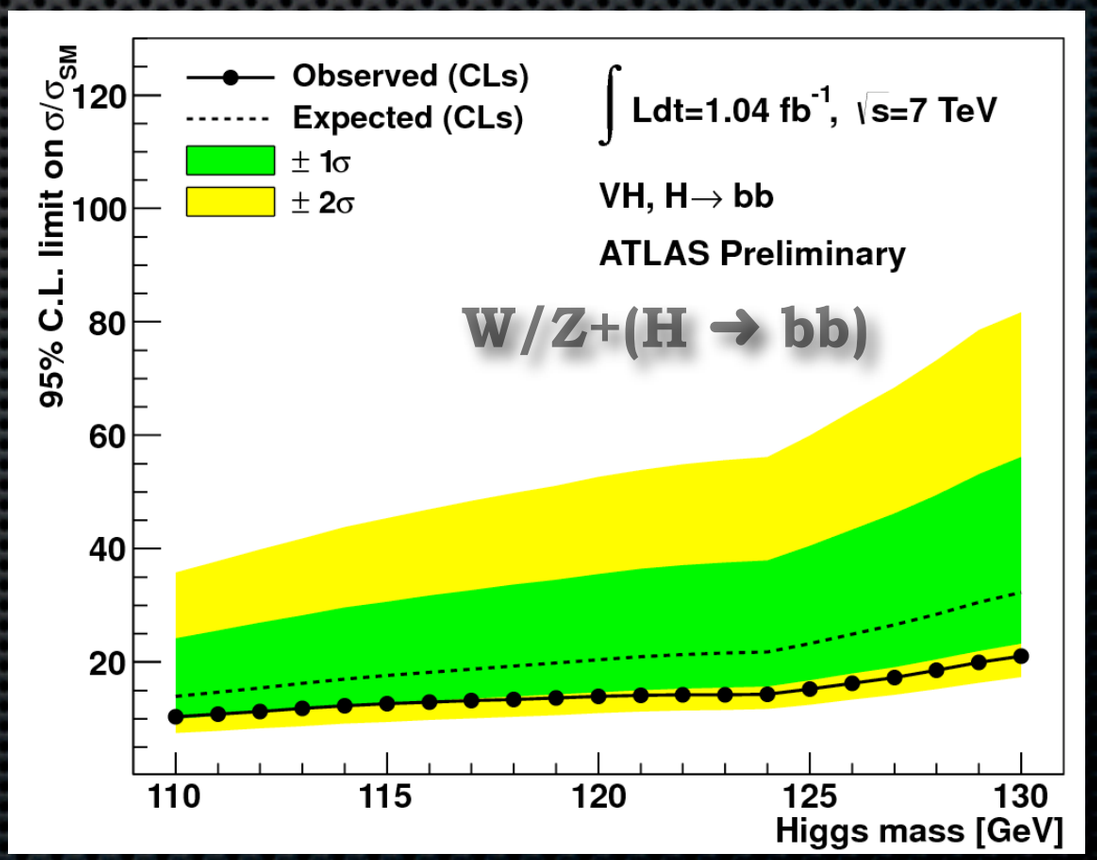
W/Z + (H → bb)

- Dominant decay mode at **low mass**
  - Huge QCD background
  - Needs associated production
- Possibility of measuring directly Higg to **quark couplings**

W/Z + (H → bb): Limits

- **Select W or Z (leptonic) events --> trigger event**
  - Require exactly two b-tagged jets with p_T > 25 GeV
  - Bump hunting in the m_{bb} spectrum
- **Major backgrounds**
  - Z+jets, W+jets, top and dibosons

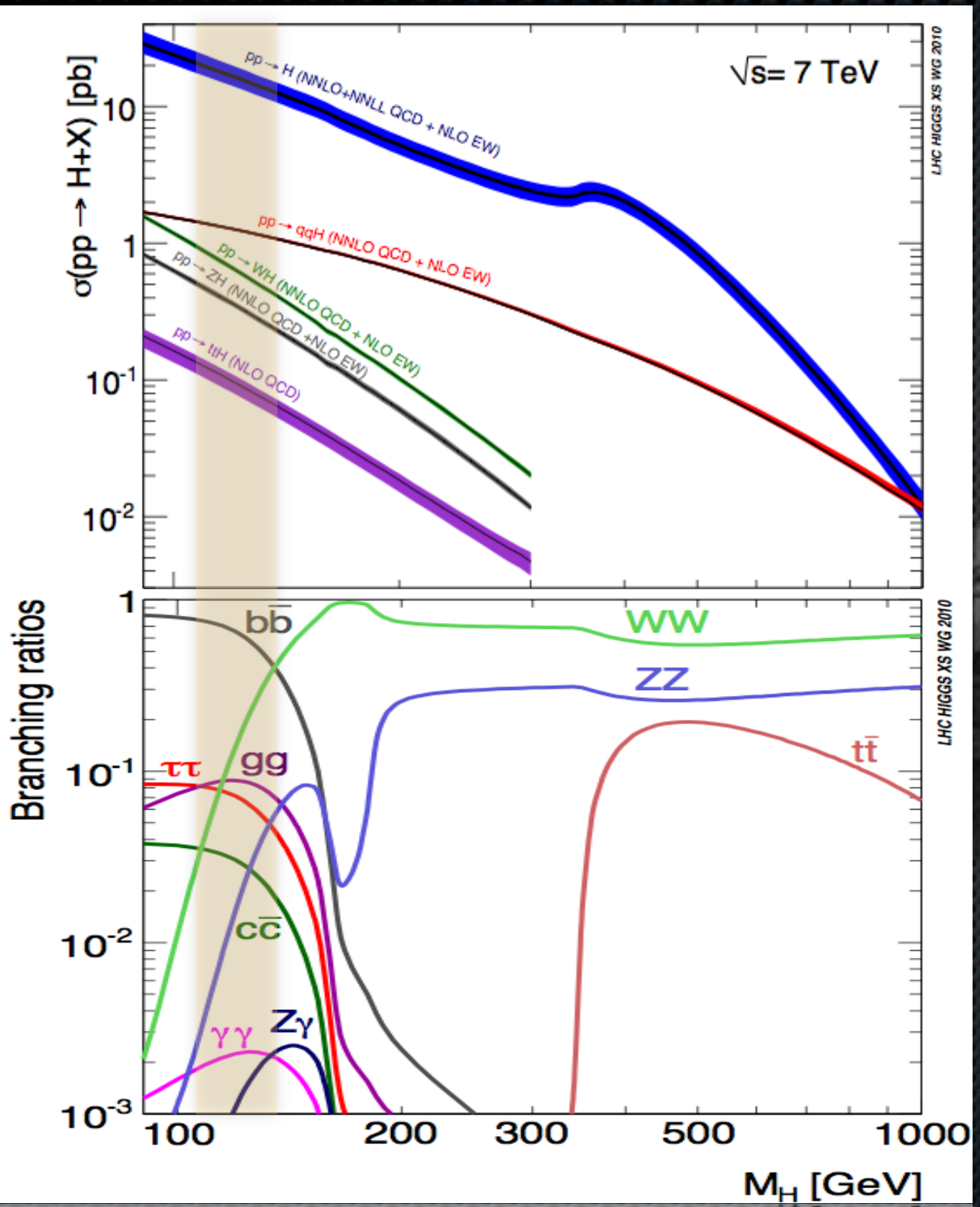


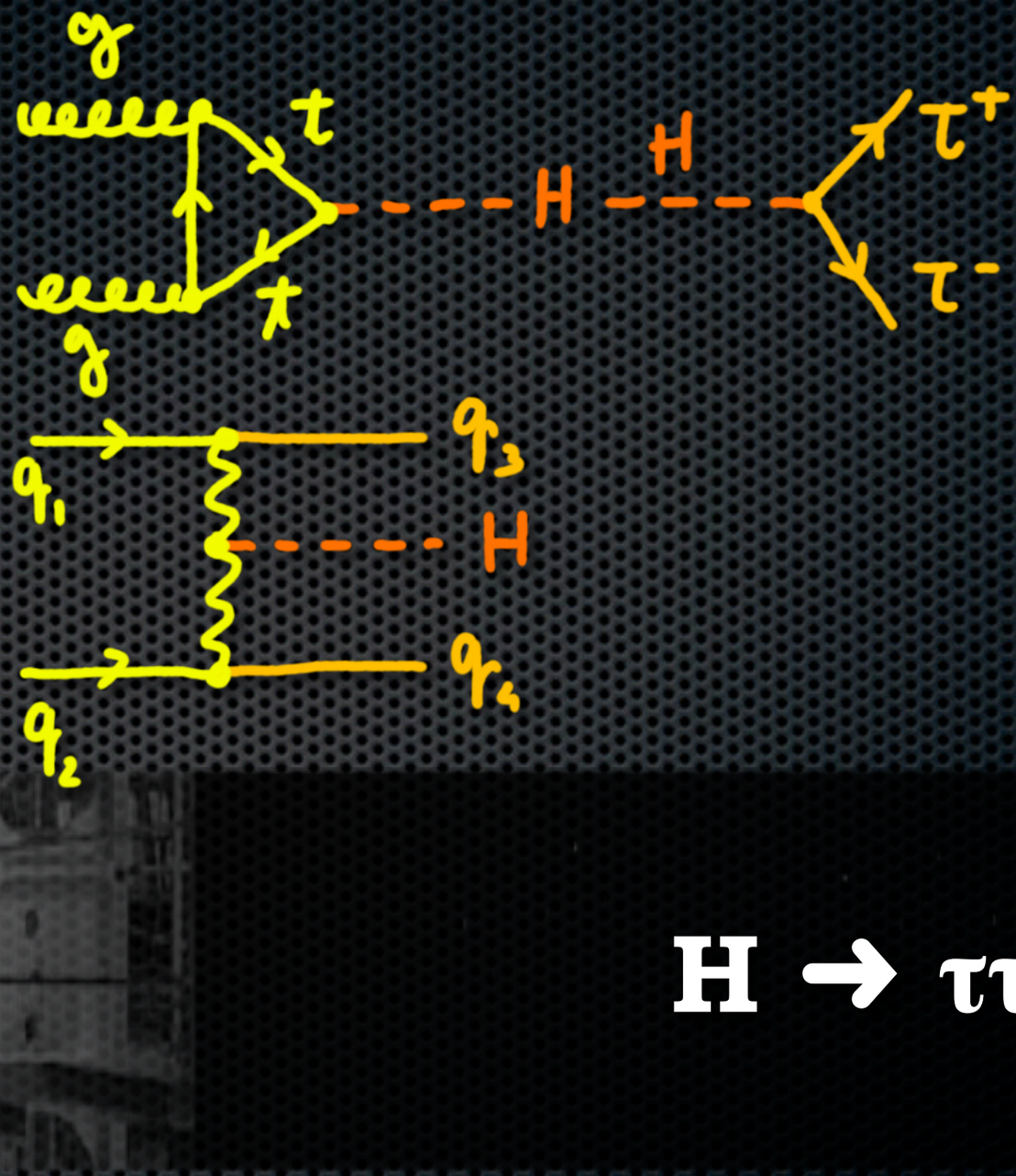


Exclusion limit: 10-15 × σ_{SM}

Improvements expected with boosted b-jet pairs

m_H = 110-140 GeV

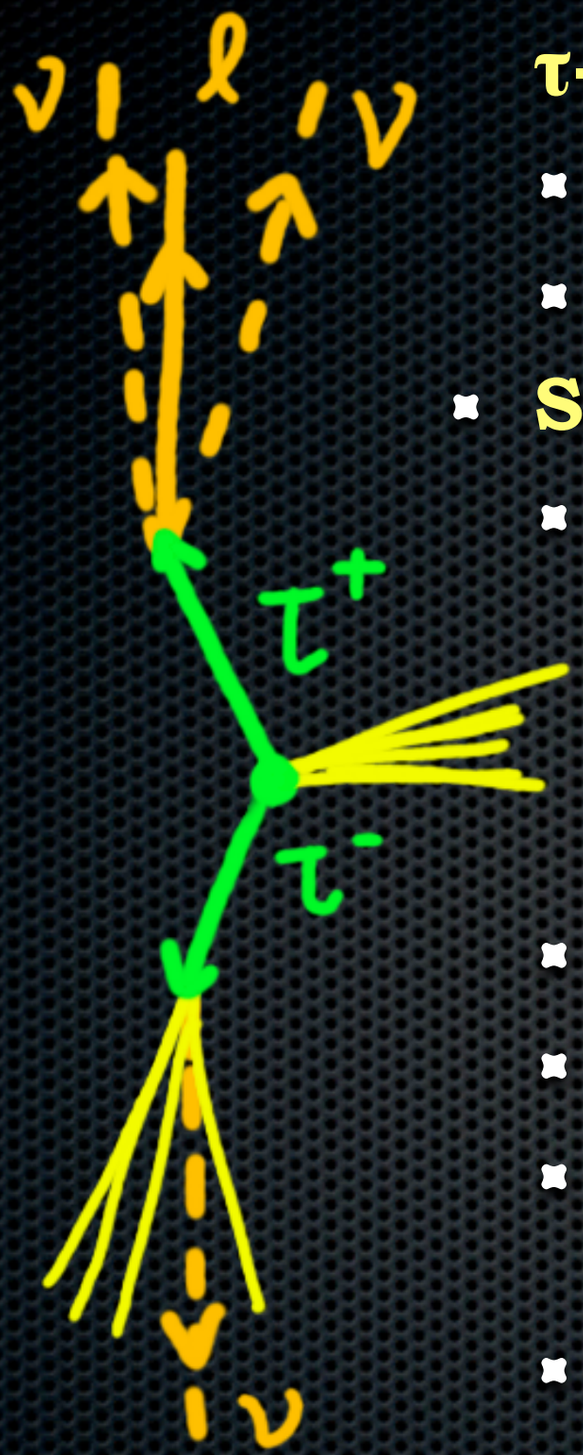




$H \rightarrow \tau\tau$

- Higgs produced in association with jets
  - Gluon fusion at NLO
  - VBF at LO

H → ττ: Event Selection

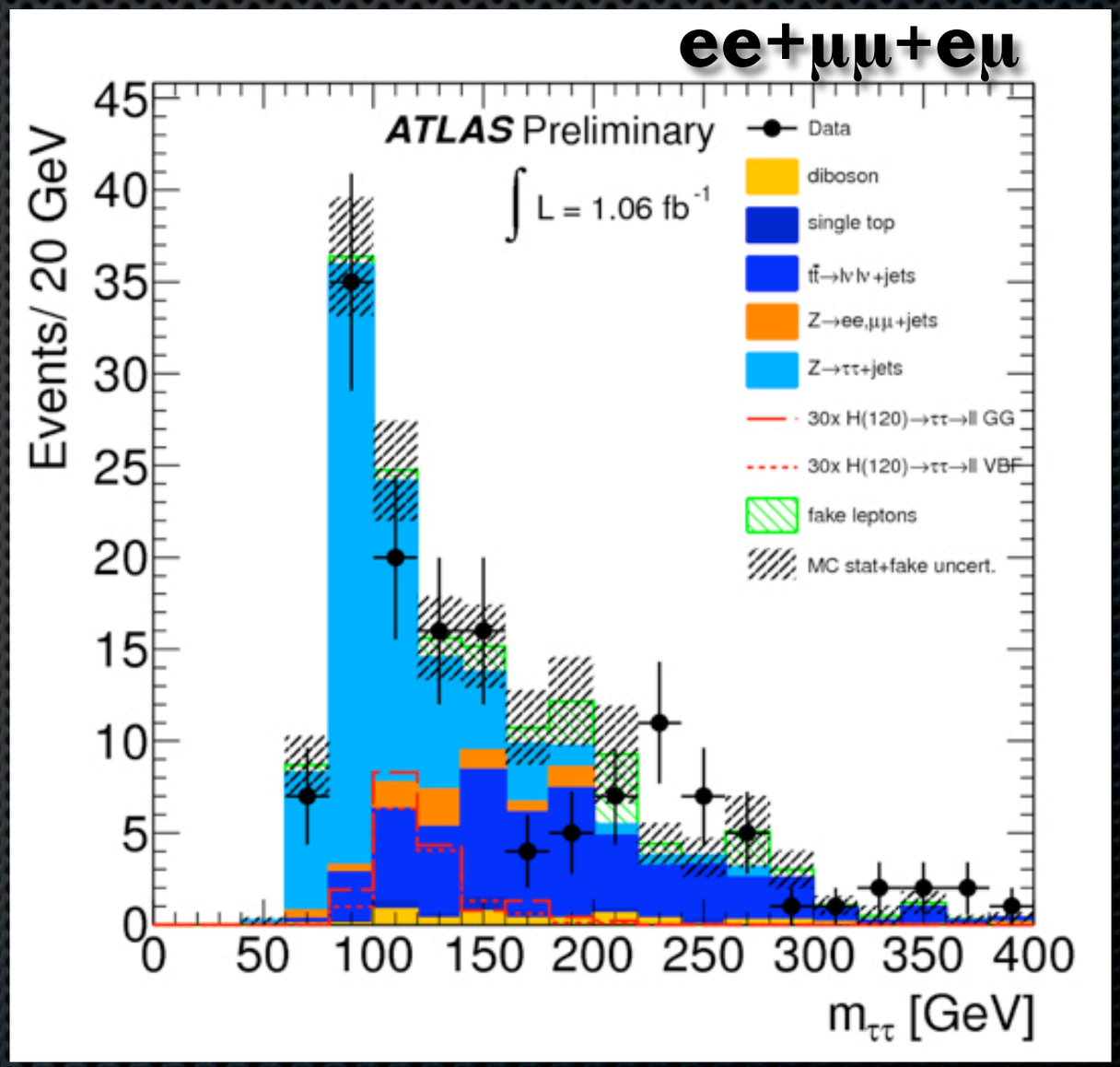


- **Three classes of events depending on the τ-decay**
  - **$l\tau_{had}3\nu$: lepton and hadronic tau decay**
  - **$l^+l^-4\nu$: lepton-lepton tau decay**
- **Selection for $l^+l^-4\nu$:**
  - **2 electrons, or 2 muons, or 1e1μ**
  - **$p_T^e > 15$ GeV, $|\eta^e| < 2.47$**
  - **$p_T^\mu > 10$ GeV, $|\eta^\mu| < 2.5$**
  - **opposite charge**
  - **At least one jet with $p_T > 40$ GeV, $|\eta| < 4.5$**
  - **$E_T^{miss} > 30$ GeV for 2e and 2μ, > 20 for 1e1μ**
  - **Reconstruct τ momentum in collinear approximation**
  - **Apply dilepton invariant mass and topological cuts ($\Delta\phi_{ll}$, $m_{\tau\tau}$, $m_{\tau\tau j}$)**

H → ττ: Results

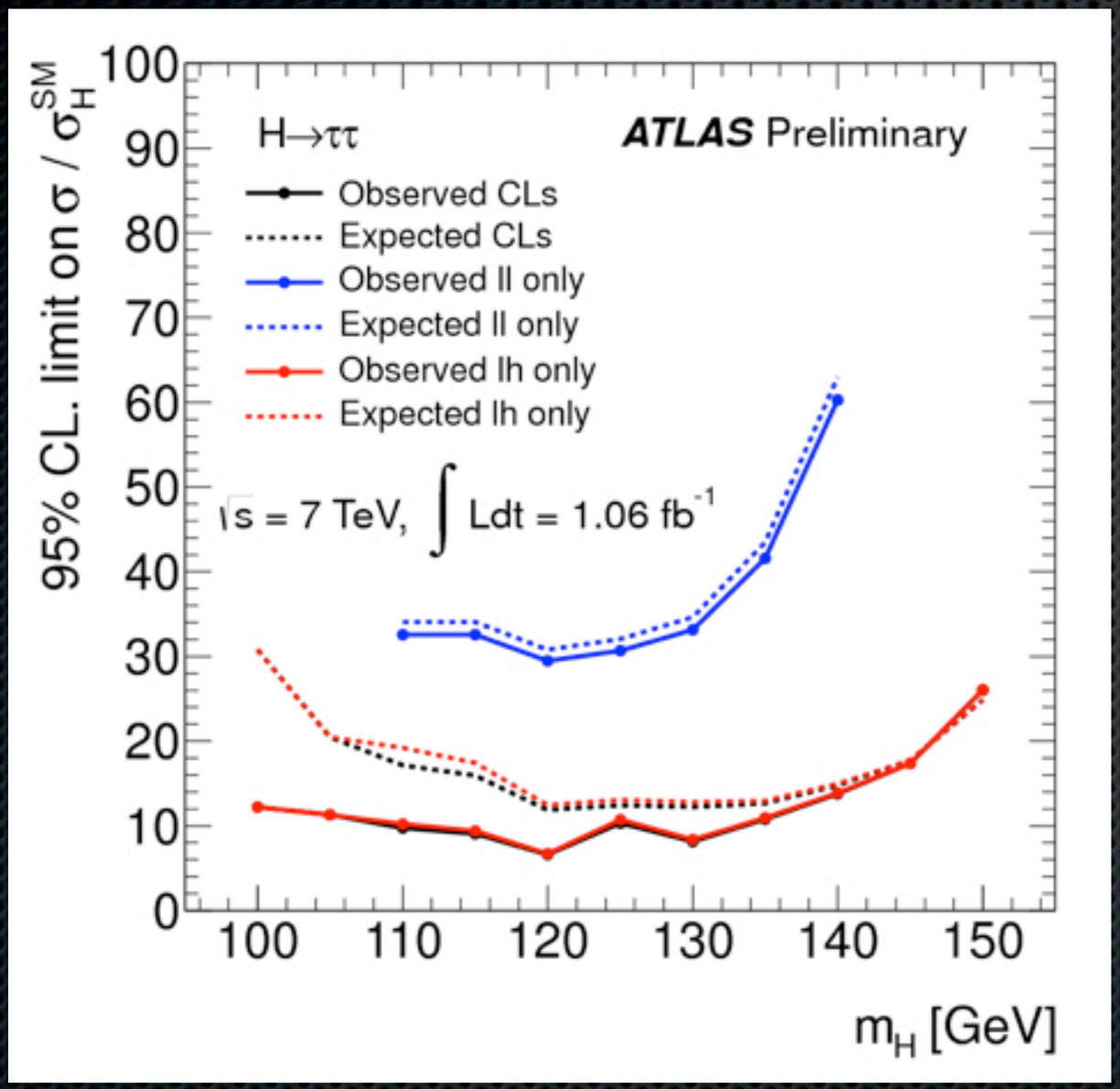
- **Major backgrounds:**
  - Z → ll + jets
  - Z → ττ + jets
    - mostly irreducible
  - ttbar, single top, QCD jets
  - fake lepton backgrounds, and Z --> ττ estimated from data; others from MC

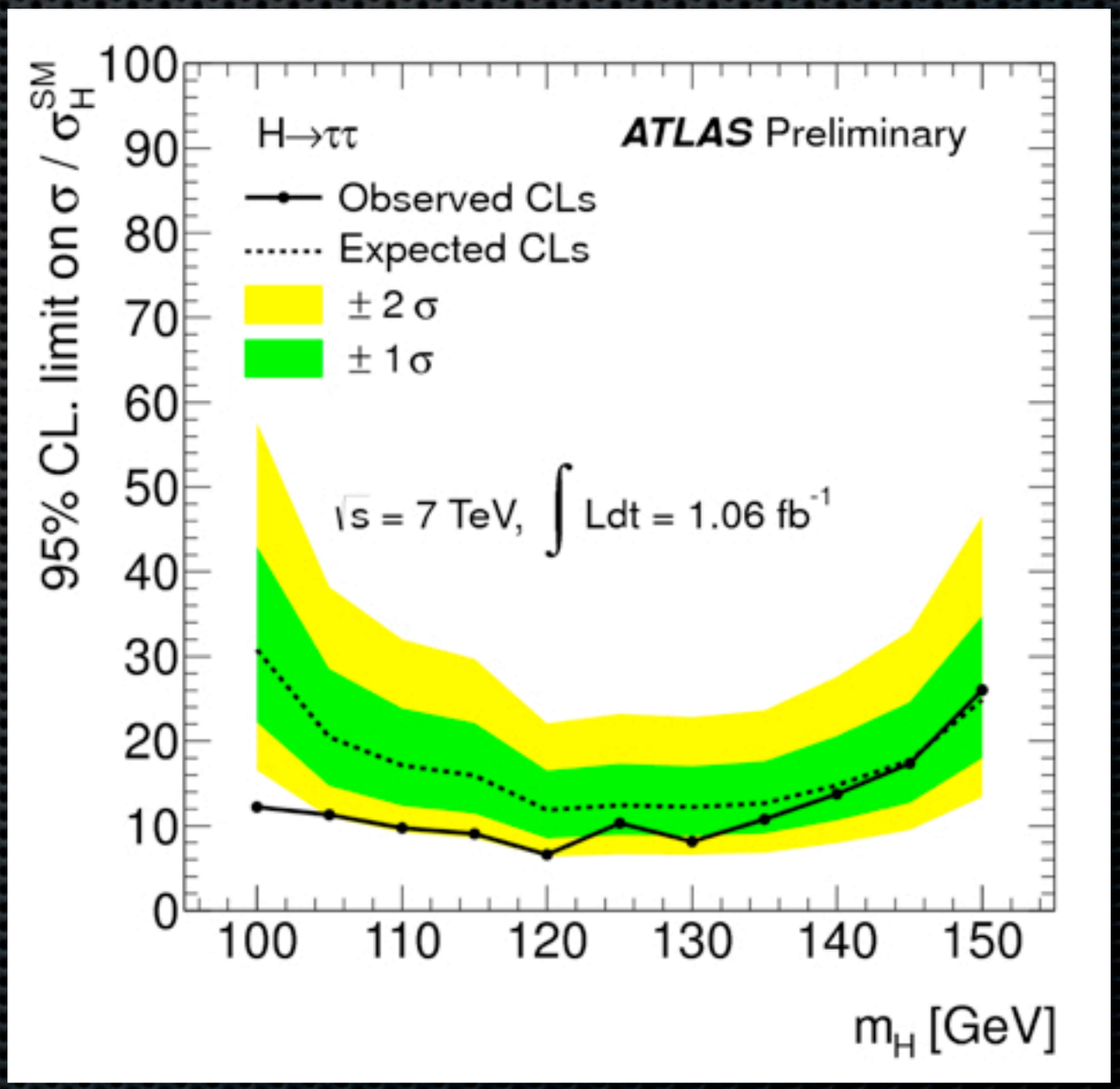
- **Systematic uncertainties**
  - Dominated by JES
    - Background: +7.0%, -9.8%
    - Higgs (120 GeV): +4.1%, -7.8%



Signal:
100 < $m_{\tau\tau}$ <150 GeV

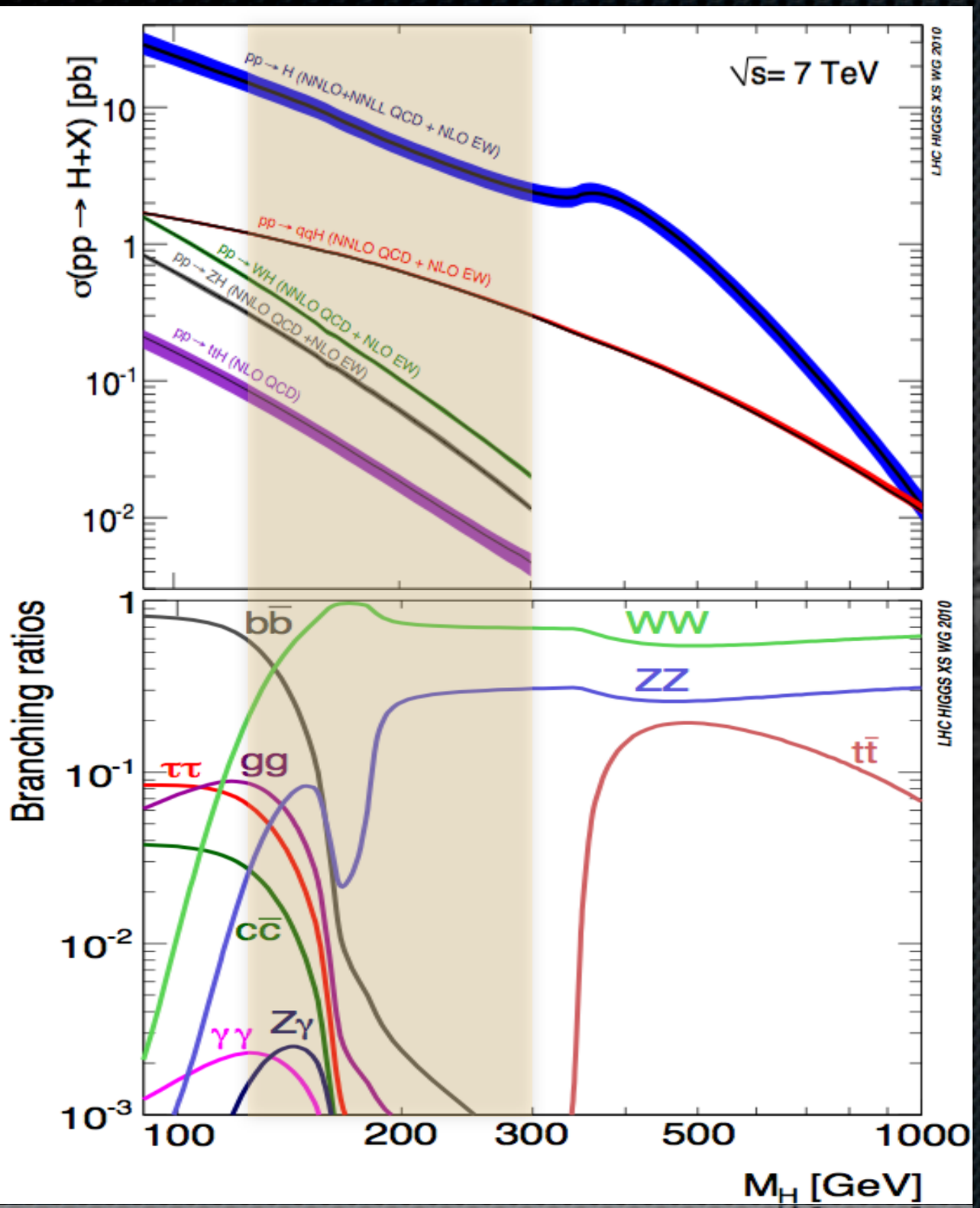
H → ττ: Exclusion limits

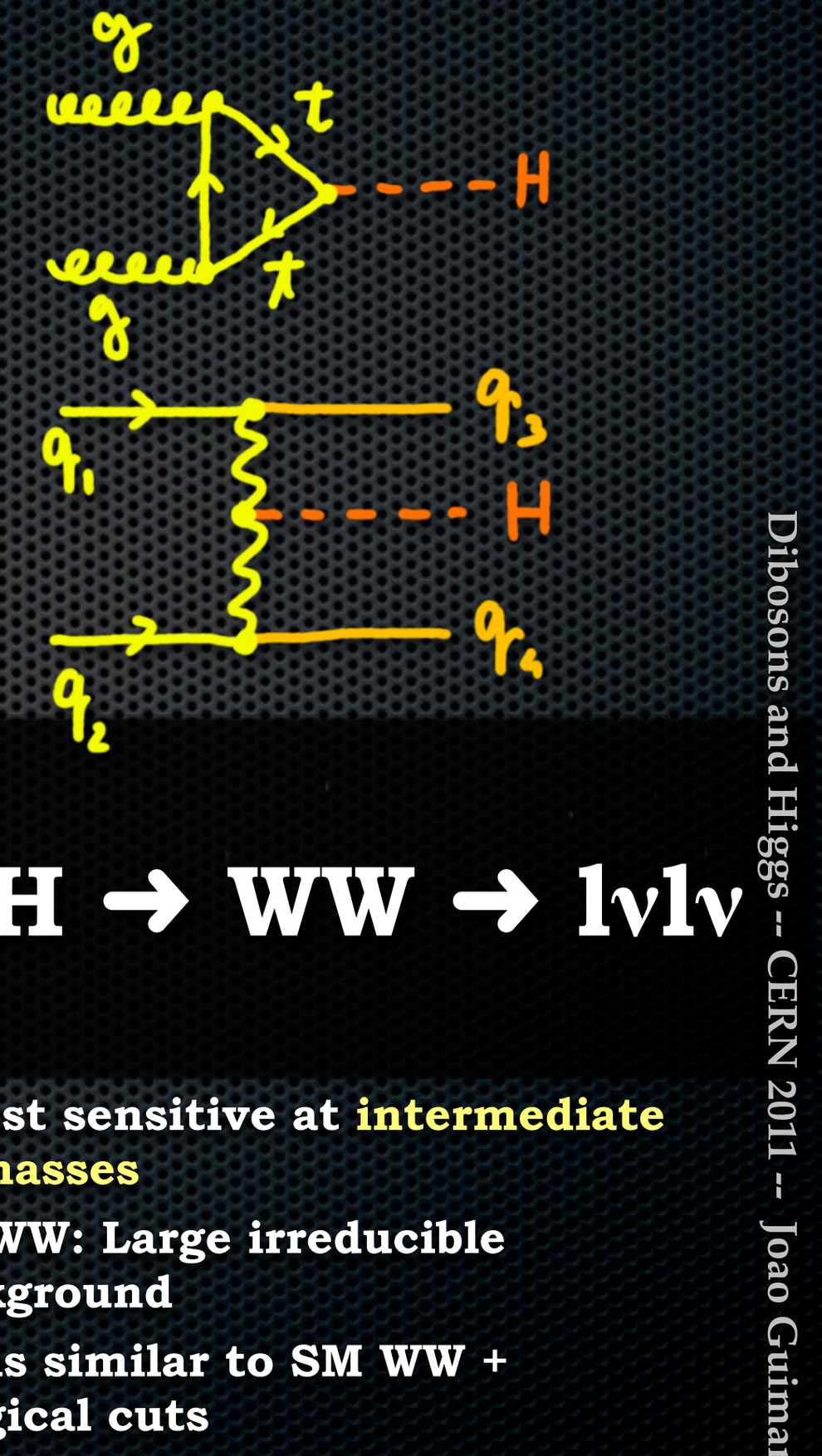




Exclusion limit: 7-15 × σ_{SM}

m_H = 130-200 GeV





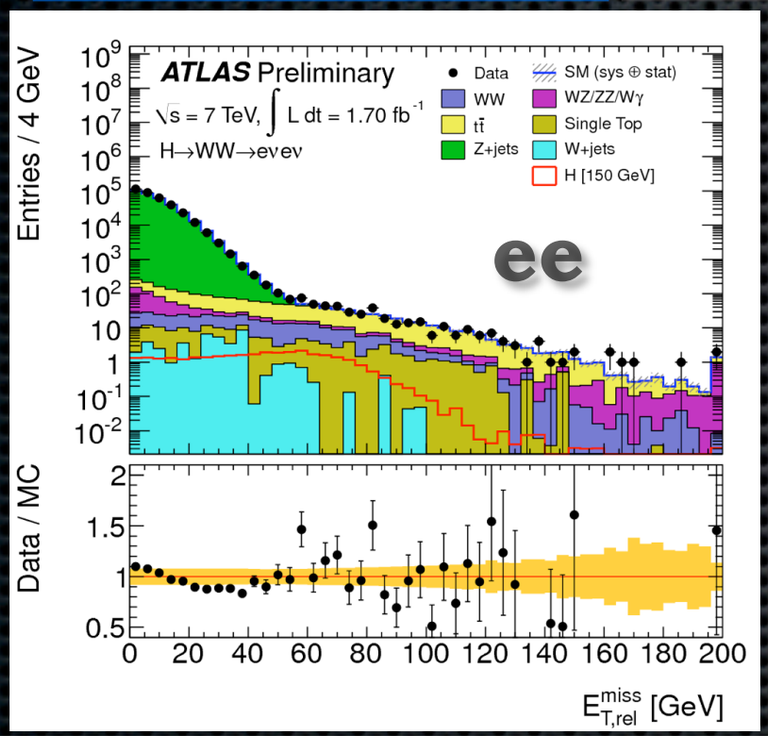
H → WW → lνlν

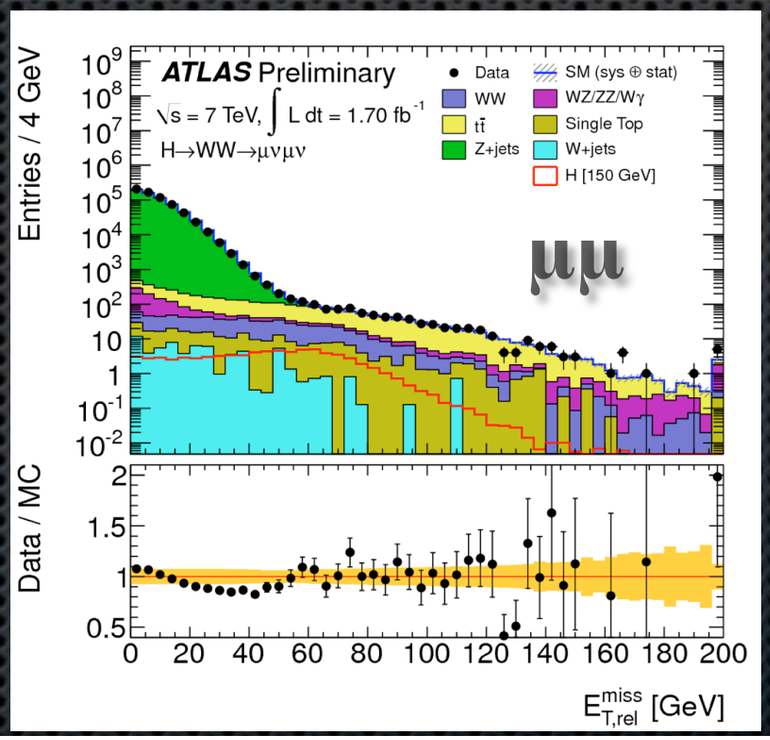
- The most sensitive at **intermediate Higgs masses**
  - SM WW: Large irreducible background
- Analysis similar to SM WW + topological cuts
- Reconstruction of invariant mass not possible

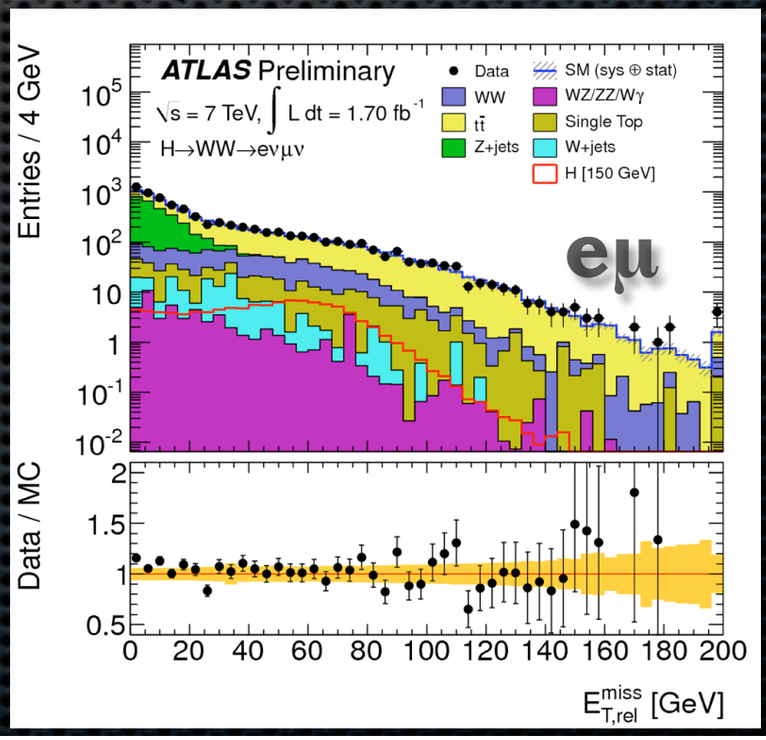
H → WW → lνlν: Event Selection

- **Event selection similar to SM WW:**
  - **Two high-pt leptons and large missing energy**

(GeV)	e-e	μ-μ	e-μ
p_T leading	25	25	25
p_T subleading	20	15	e:15, μ:20
E_T^{miss} rel	40	40	25







	WW	$Z/\gamma^* + \text{jets}$	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
$m_{\ell\ell} > 15$ GeV, $m_{e\mu} > 10$ GeV	1380 ± 100	970000 ± 70000	6200 ± 600	630 ± 70	1200 ± 100	970000 ± 70000	997813
$\lvert m_Z - m_{\ell\ell}\rvert > 15$ GeV	1220 ± 80	91000 ± 7000	5500 ± 600	560 ± 60	92 ± 9	98000 ± 7000	104253
$E_{\text{T,rel}}^{\text{miss}}$	660 ± 50	300 ± 200	2700 ± 300	310 ± 40	28 ± 4	4000 ± 500	4051

H → WW → lνlν: Event Selection

After the MET cut, divide the events into two categories

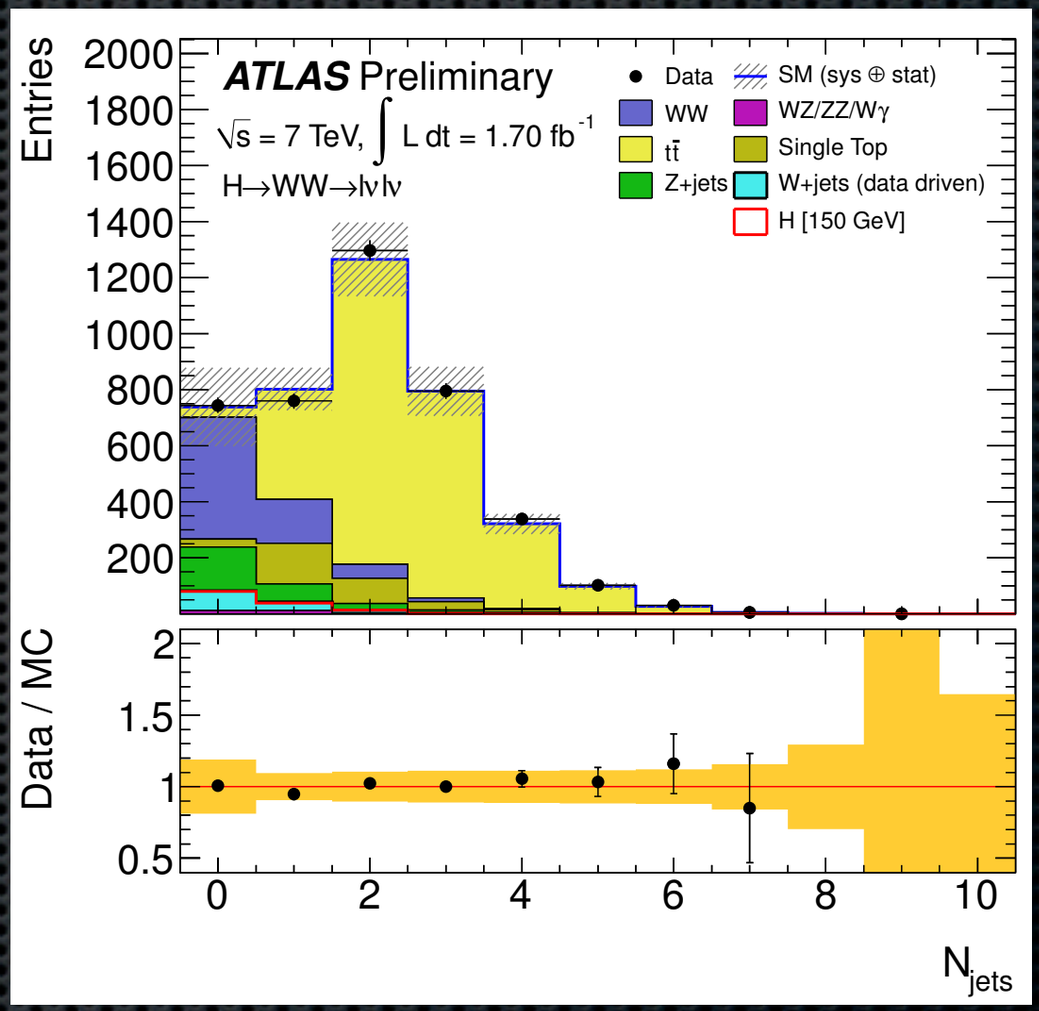
1. **Events with exactly one jet**
   - p_T > 25 GeV, $|\eta| < 4.5$
   - apply b-tag veto
2. **Events with no such jets**

Then....

- **Apply topological cuts**
  - m_{ll}, $\Delta\phi_{ll}$ and $p_T(ll)$
- **Reconstruct transverse mass**

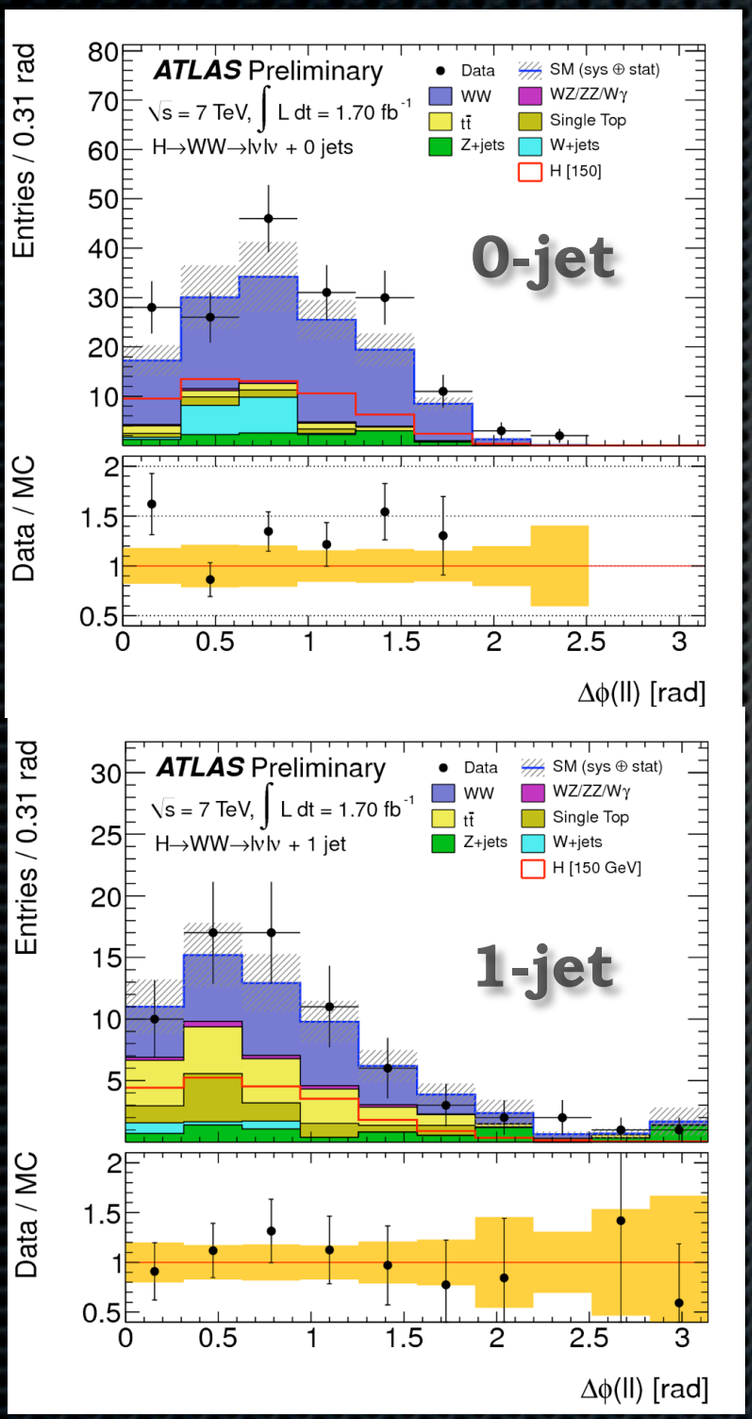
$$m_{\mathrm{T}} = \sqrt{(E_{\mathrm{T}}^{\ell\ell} + E_{\mathrm{T}}^{\mathrm{miss}})^2 - (\mathbf{p}_{\mathrm{T}}^{\ell\ell} + \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}})^2}$$

- **Apply cut:**
  - $0.75 \times m_H < m_T < m_H$

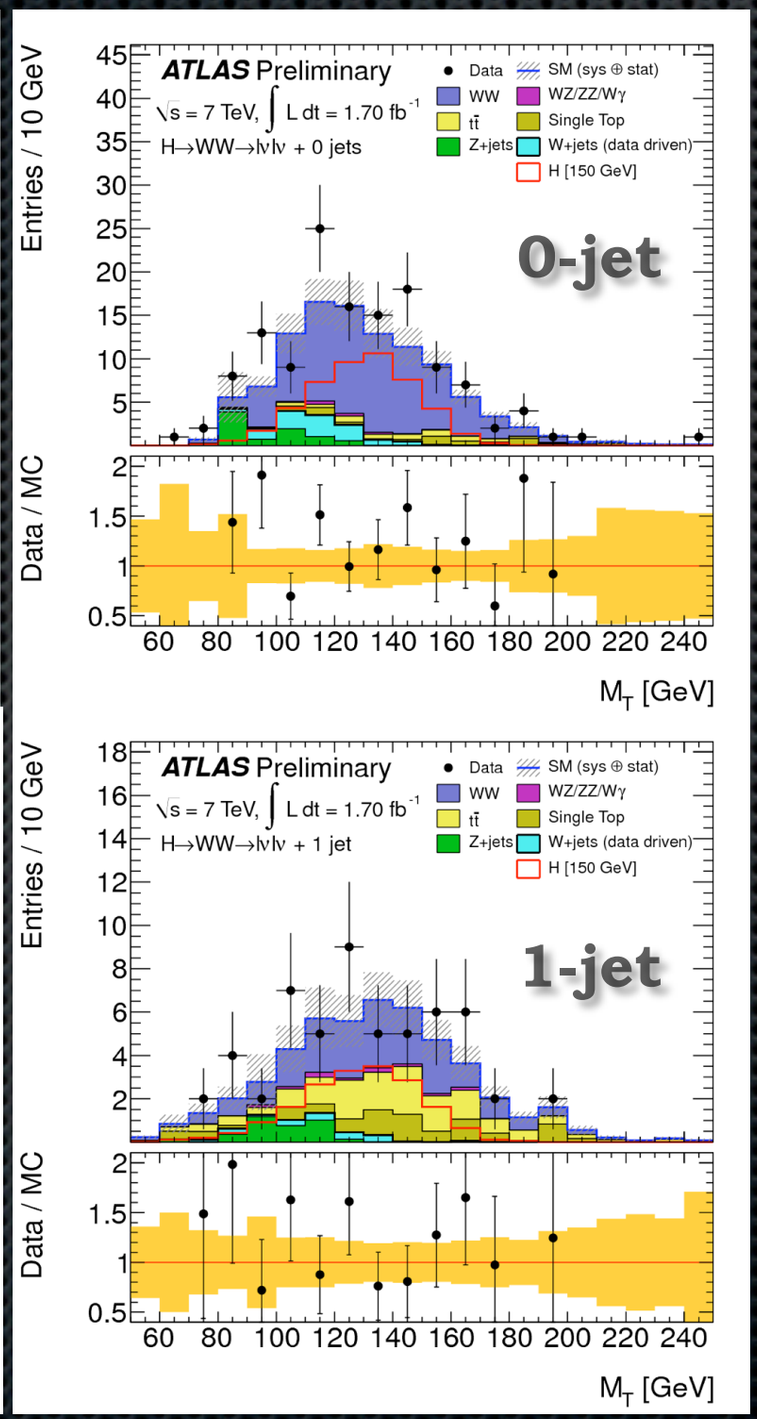


H → WW → lνlν: Event Selection

Dilepton azimuthal angle ($\Delta\phi_{ll}$)



Transverse mass (m_T)



Final event yield for m_H = 150 GeV

	WW	ttbar	Total SM back.	Data	Higgs m_H=150
0-jet	43±6	2.2±1.4	53±9	70	34±7
1-jet	10±2	6.9±1.9	23±4	23	12±3

(W+jets only estimated with data driven method)

H → WW → lνlν: Background

- **The two largest backgrounds, SM WW and top production, are normalized to data**
  - **Measure background in control region enriched in WW or top events**
  - **Extrapolate the C.R. measurement to the signal region using MC shapes**

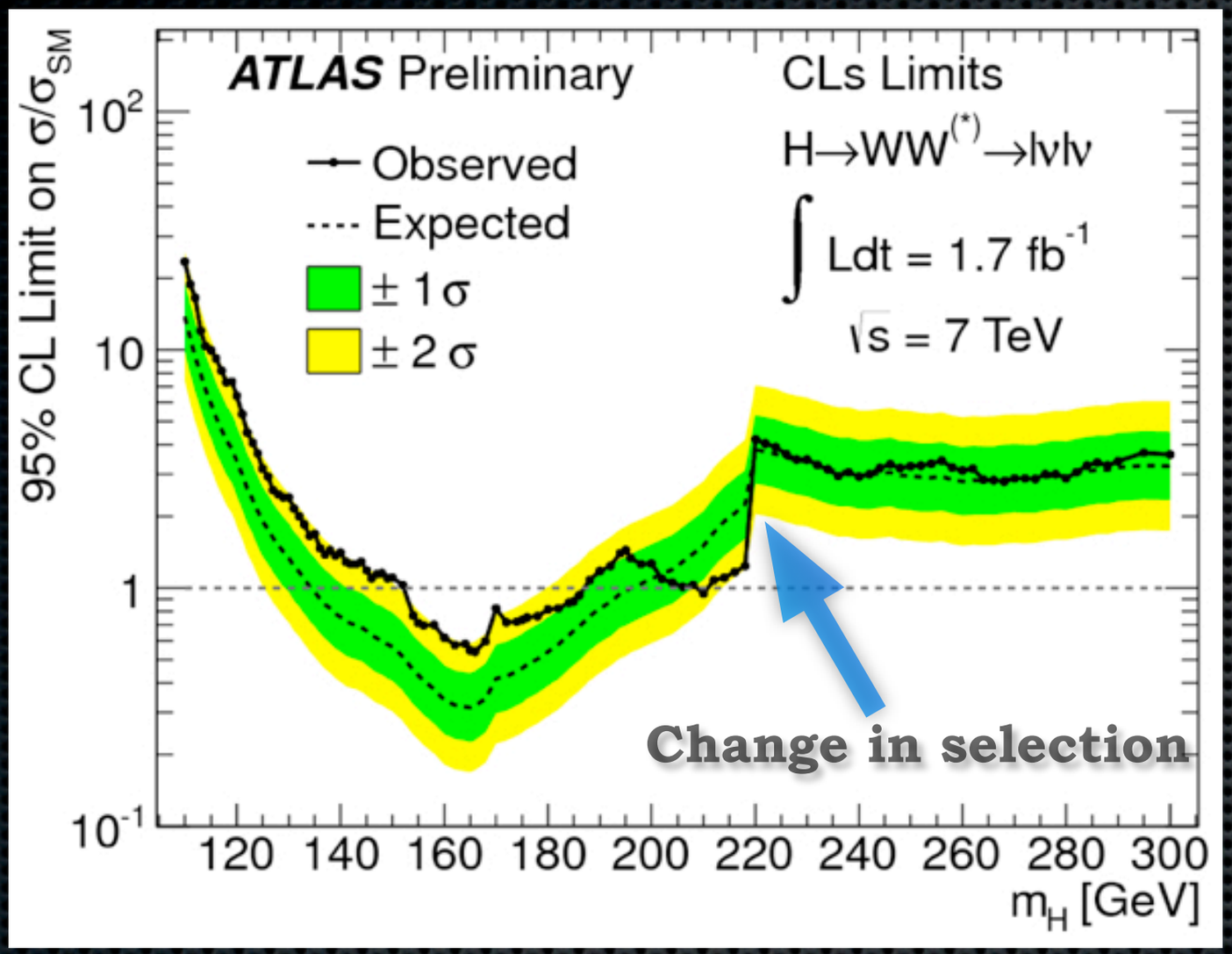
$$N_{data}^{S.R.} = \alpha \times N_{data}^{C.R.}, \qquad \alpha = \frac{N_{MC}^{S.R.}}{N_{MC}^{C.R.}}$$

- **W+jets background entirely determined from data**
- **Other (smaller backgrounds) are taken from Monte Carlo**
  - **Apply scale factor to Drell-Yan MC for potential E_T^{miss} mismodelling**

Control Region	MC expectation	Observed
WW 0-jet	250±50	237
WW 1-jet	139±18	144
Top 1-jet	350±100	316

H → WW → lνlν: Exclusion limit

H+0 jet and H+1 jet channels

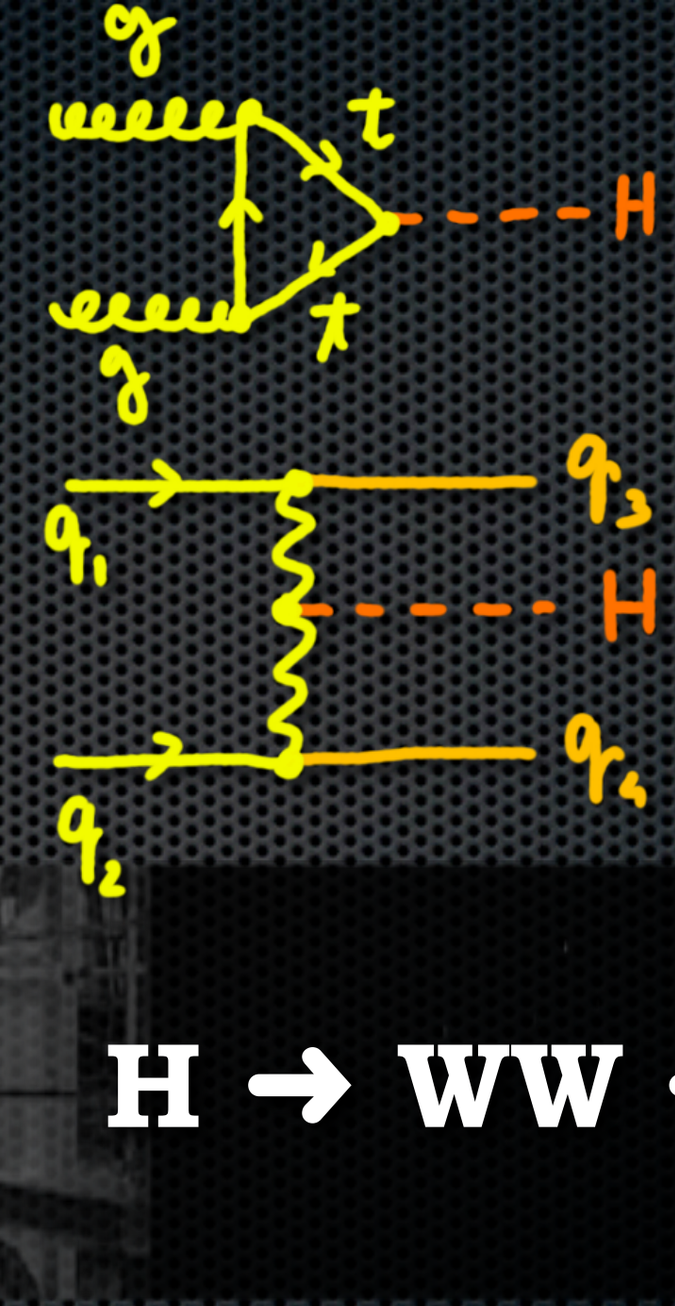


Improvements since EPS

Additional data
Optimization for M_H > 220 GeV
New b-tagging algoritm

- **A SM Higgs boson with 154 < mH < 186 GeV is excluded at 95% CL**
  - **Expected exclusion mass range is 135 < m_H < 196 GeV**
  - **The observed limit is within 2σ the expected one in the mass range 130-150 GeV**

m_H = 240-600 GeV

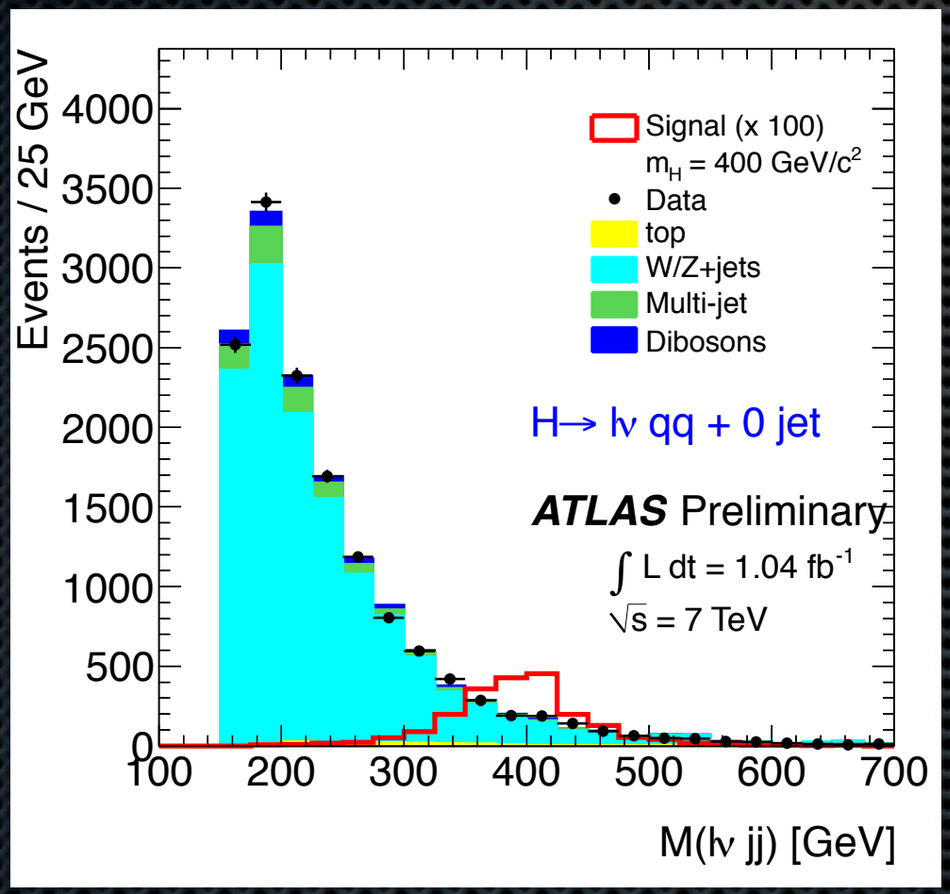


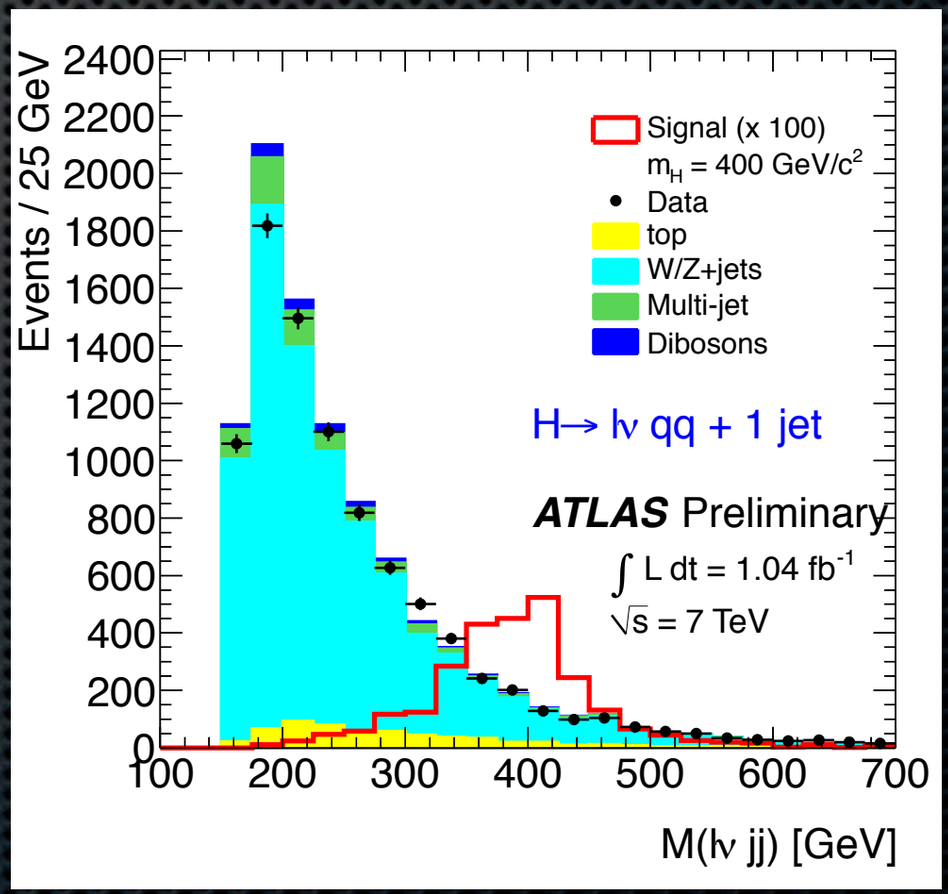
H → WW → lνqq

- Sensitive only to high-mass Higgs
  - Large QCD background at lower masses

H → WW → lνqq: Event Selection

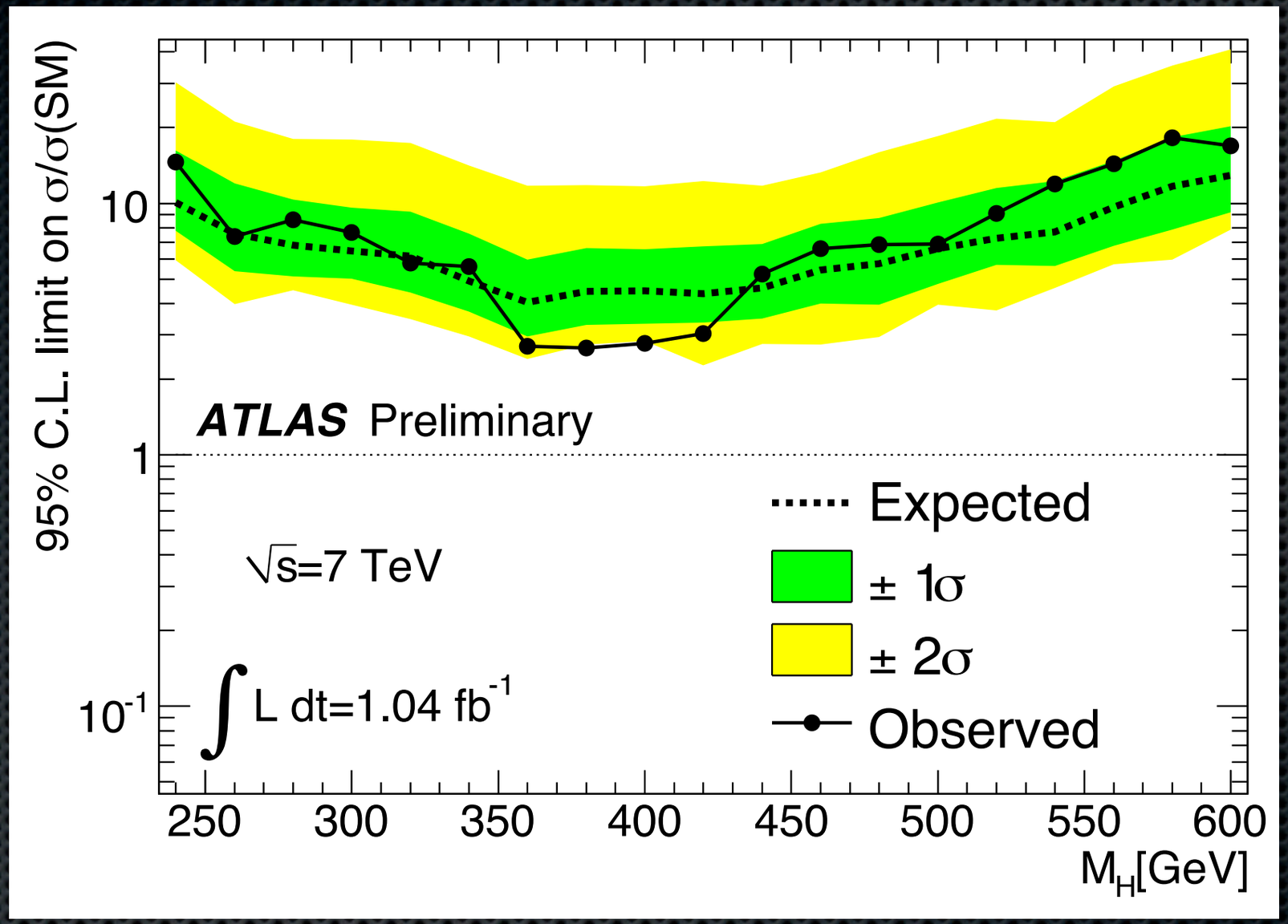
- **Selection:**
  - Exactly **one lepton** (e or μ) with p_T > 30 GeV
  - E^T_{miss} > 30 GeV
  - Two high-p_T **jets** (p_T > 25 GeV) associated with a W
  - Reconstruct the Higgs mass: **M(lνjj)**
    - Search for a **peak** over continuous background





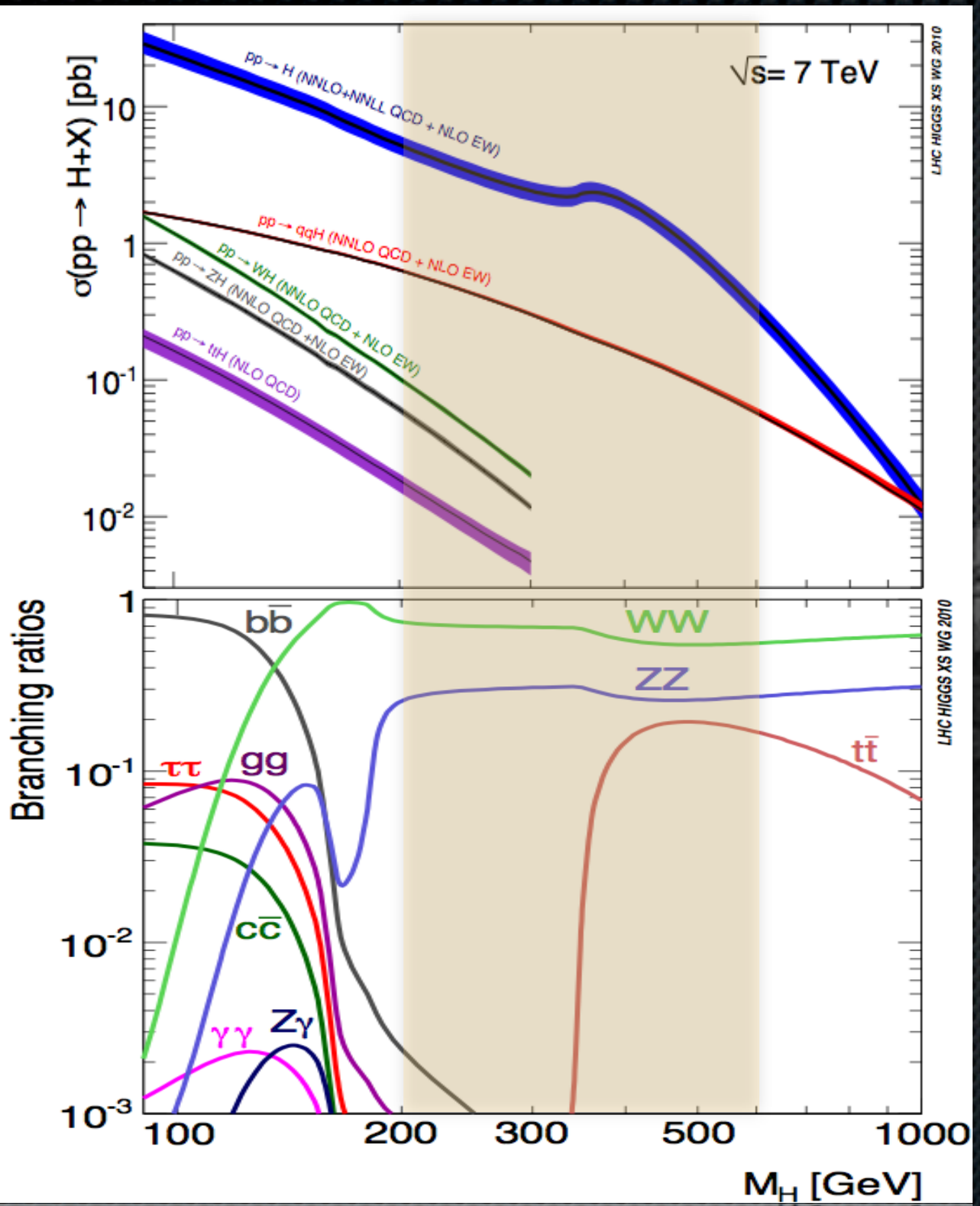
2j+3j	$N_{observed}$	N_{bkg}	N_{signal}
W → lν qq	41687	42611 ± 1223	58 ± 15

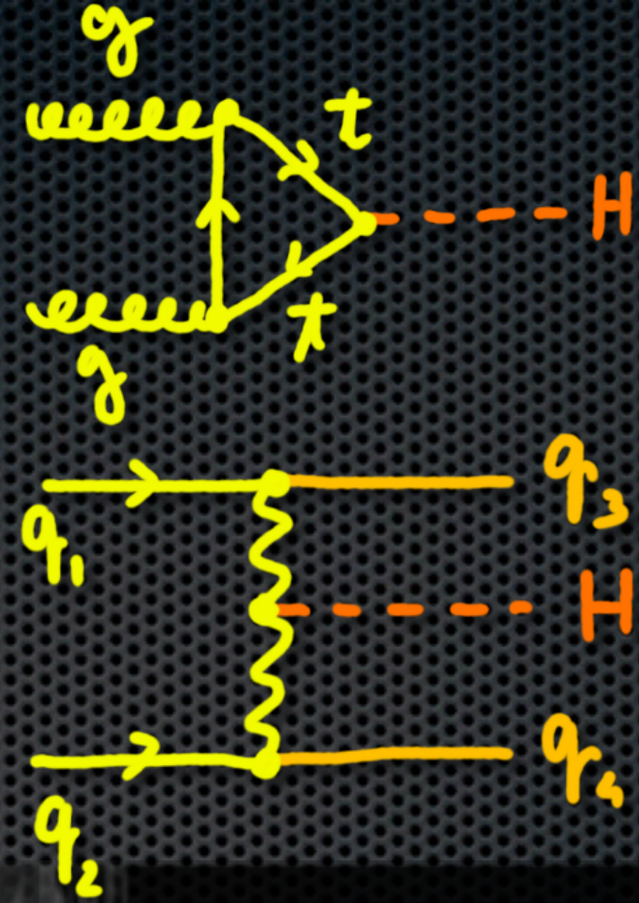
H → WW → lνqq: Limit



- m_H = 400 GeV
  - Expected upper limit: ~5 times the SM cross section
  - Observed upper limit: 2.5 times the SM cross section

m_H = 200-600 GeV



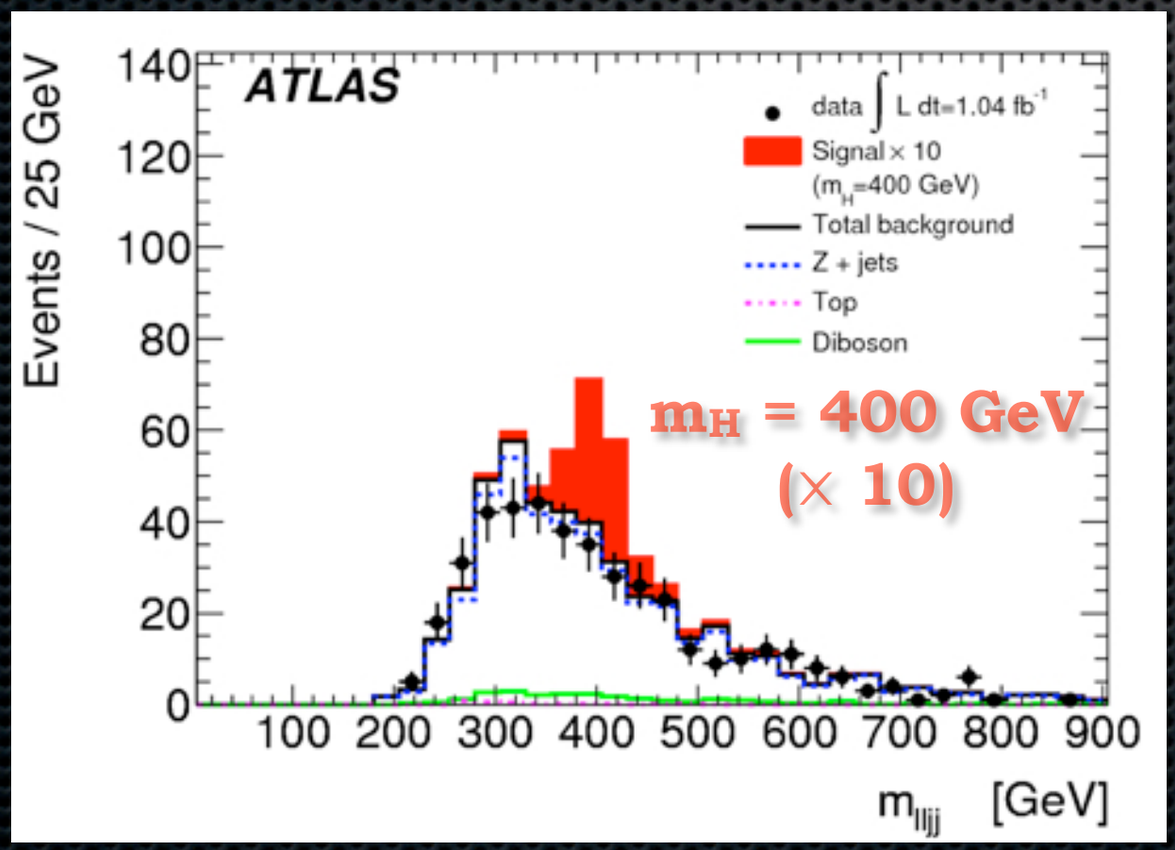


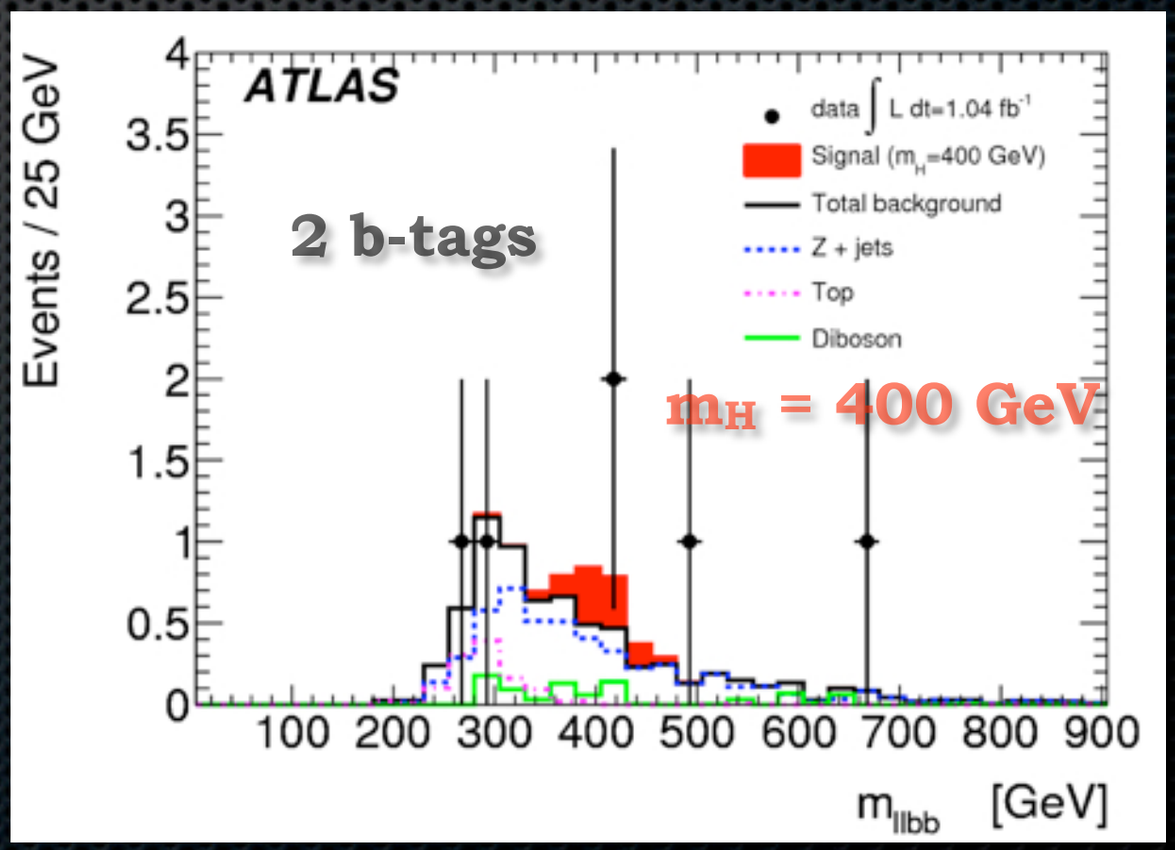
$H \rightarrow ZZ \rightarrow llqq$

- Useful for Higgs with $m_H > 2 \times m_Z$
- Acceptable signal/background ratio

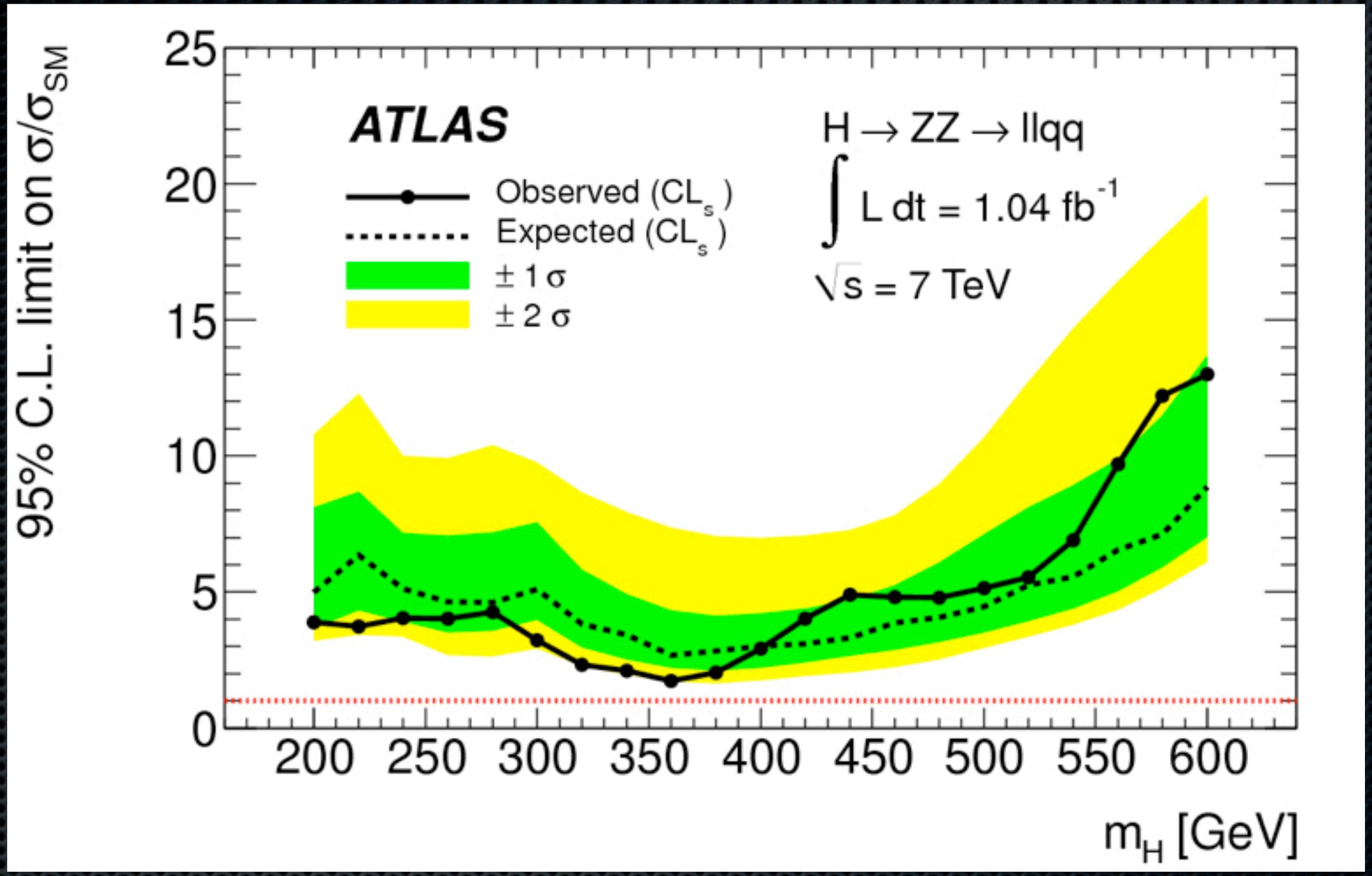
$H \rightarrow ZZ \rightarrow llqq$

- **Selection:**
  - Same flavor pair of isolated leptons (p_T > 30 GeV)
    - 76 < m_{ll} < 106 GeV
    - Third lepton veto, E_T^{miss} < 50 GeV
  - Two high-p_T jets (p_T > 25 GeV, $|\eta|$ < 2.5)
    - 70 < m_{jj} < 105 GeV
  - Reconstruct the Higgs mass: M(lljj) -- with m_{jj} scaled to m_Z
- **Main background: QCD Z+ jets**



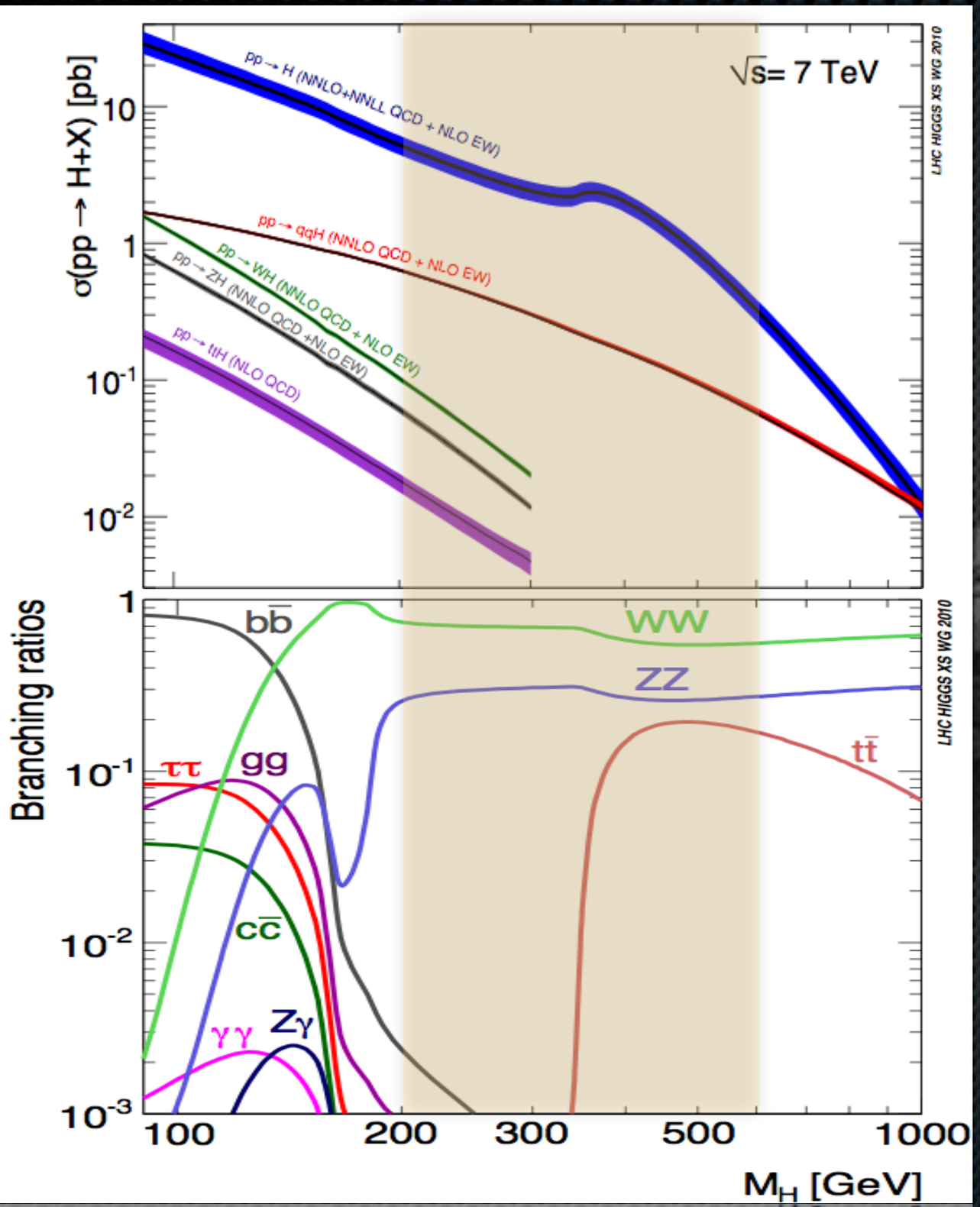


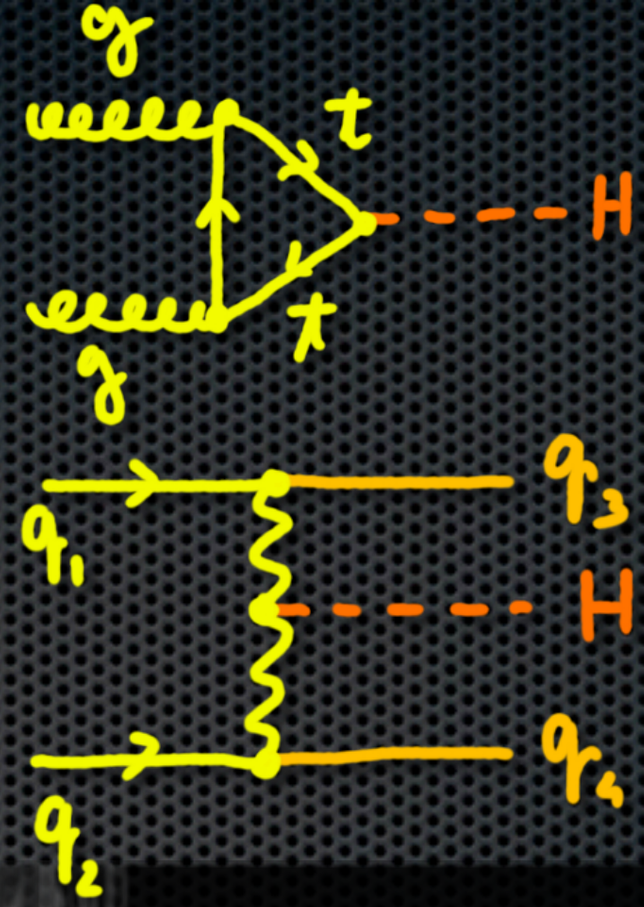
H → ZZ → llqq: Exclusion limit



- m_H = 360 GeV
  - Expected upper limit: ~2.7 × σ_{SM}
  - Observed upper limit: 1.7 × σ_{SM}

m_H = 200-600 GeV





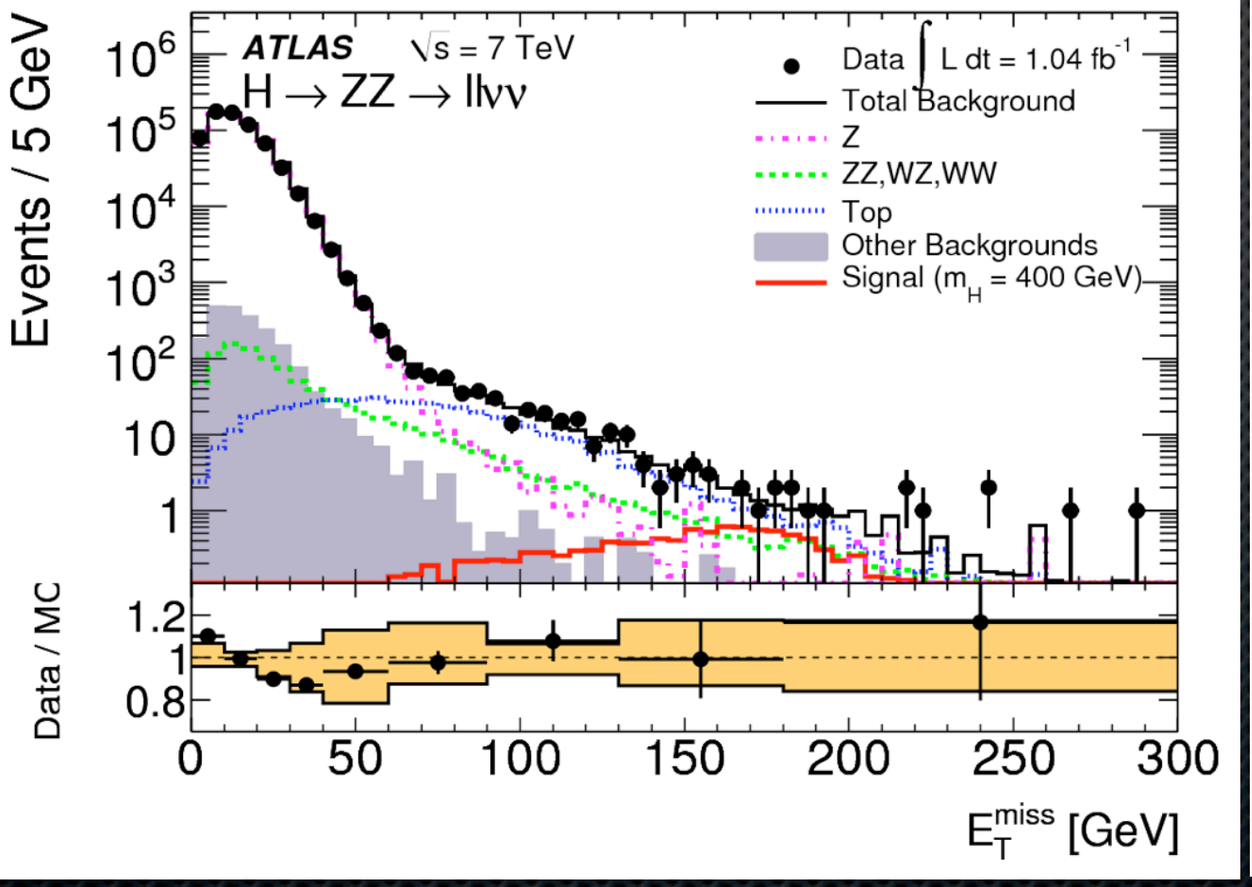
H → ZZ → llνν

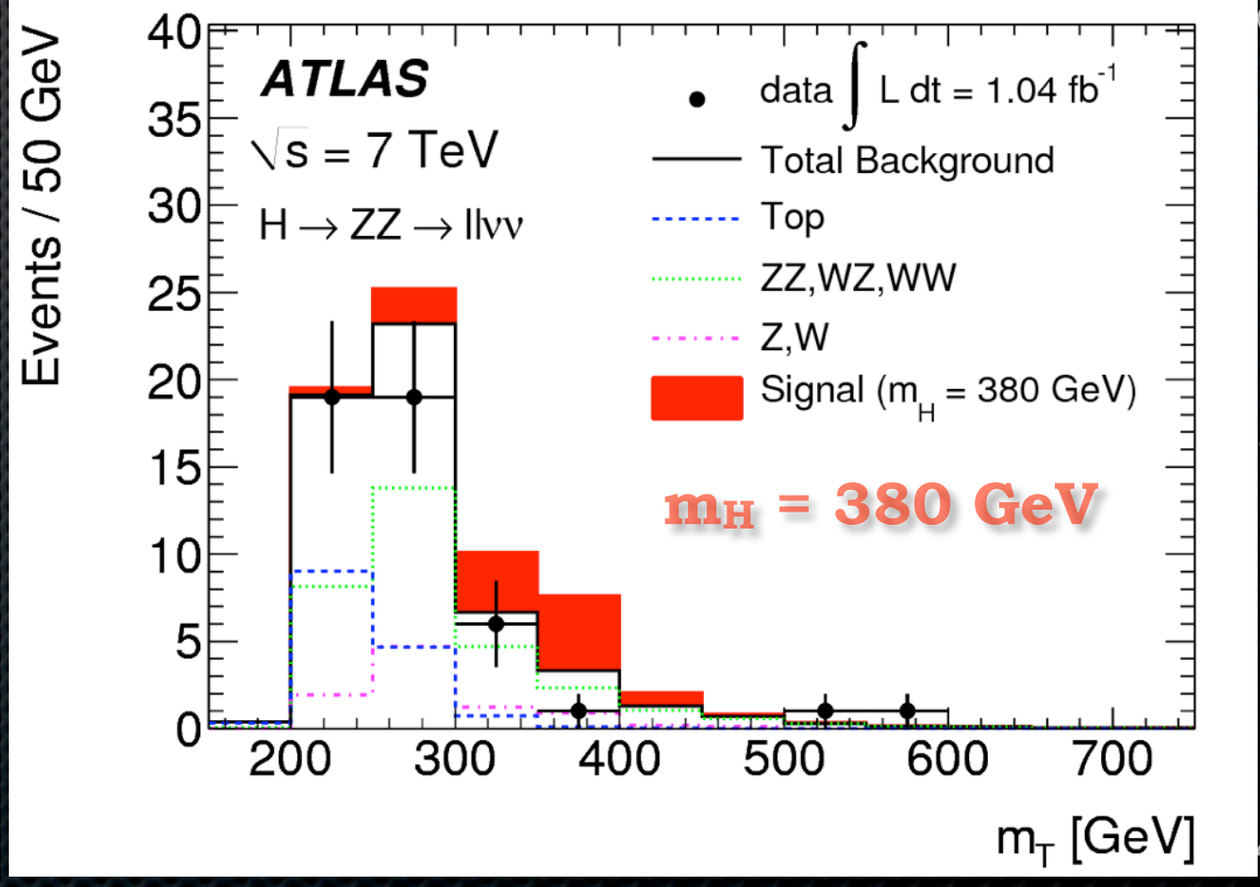
- Most sensitive channel in the high-mass region
  - Large branching fraction
  - Good separation from backgrounds
  - Main backgrounds:
    - Top and dibosons (irreducible)

$H \rightarrow ZZ \rightarrow ll\nu\nu$

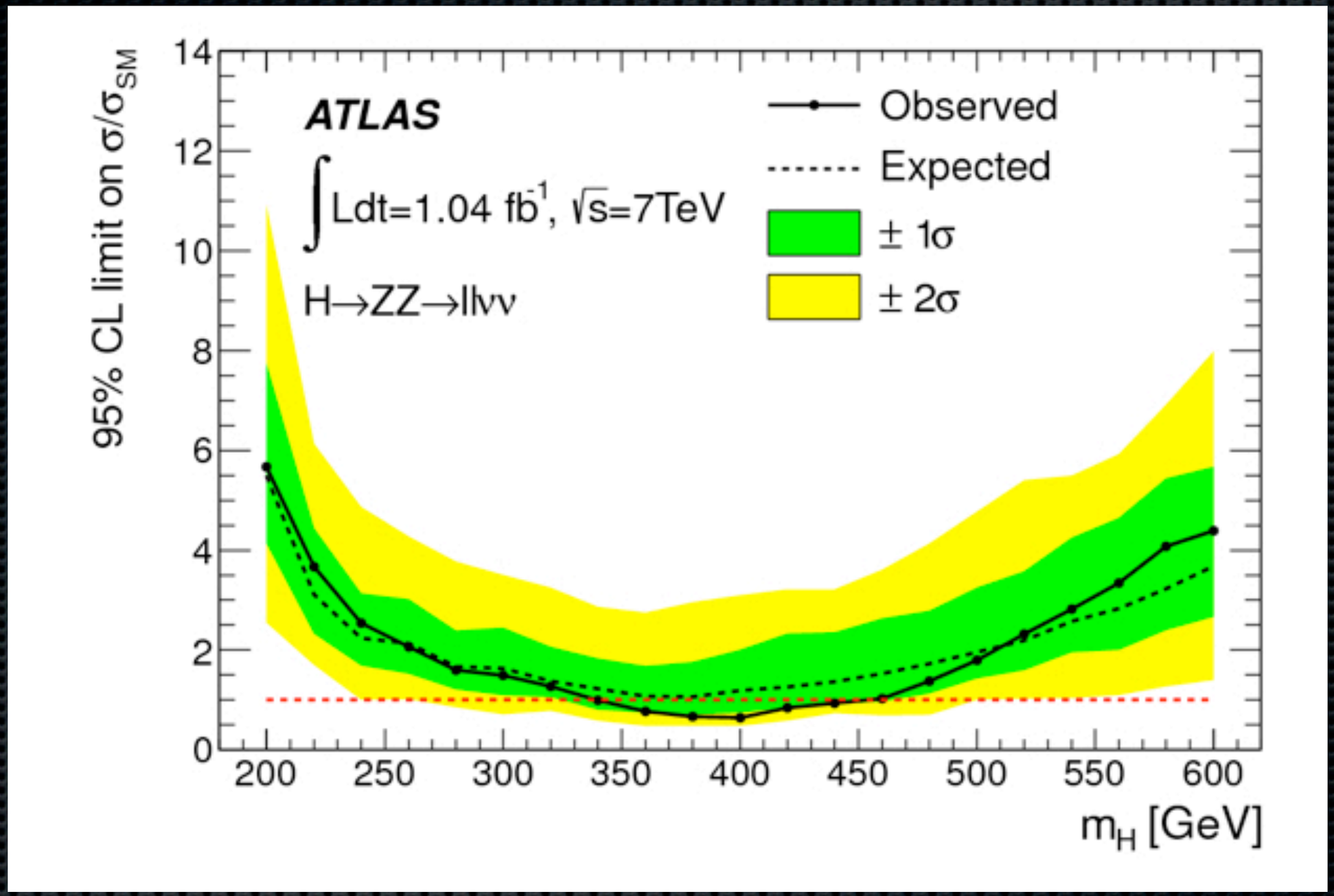
- **Selection:**
  - Same flavor OS pair of isolated leptons (p_T > 30 GeV)
    - 76 < m_{ll} < 106 GeV (orthogonal to $H \rightarrow WW \rightarrow l\nu\, l\nu$)
    - Third lepton veto, b-jet veto
  - E_T^{miss} > 66 (82) GeV -- depending on low- (high-) mass analysis
  - Topological cuts to suppress W/Z+jets QCD background

$$m_{\mathrm{T}}^2 \equiv \left[\sqrt{m_{\mathrm{Z}}^2 + |\vec{p}_{\mathrm{T}}^{\,\ell\ell}|^2} + \sqrt{m_{\mathrm{Z}}^2 + |\vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}|^2}\right]^2 - \left[\vec{p}_{\mathrm{T}}^{\,\ell\ell} + \vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}\right]^2$$



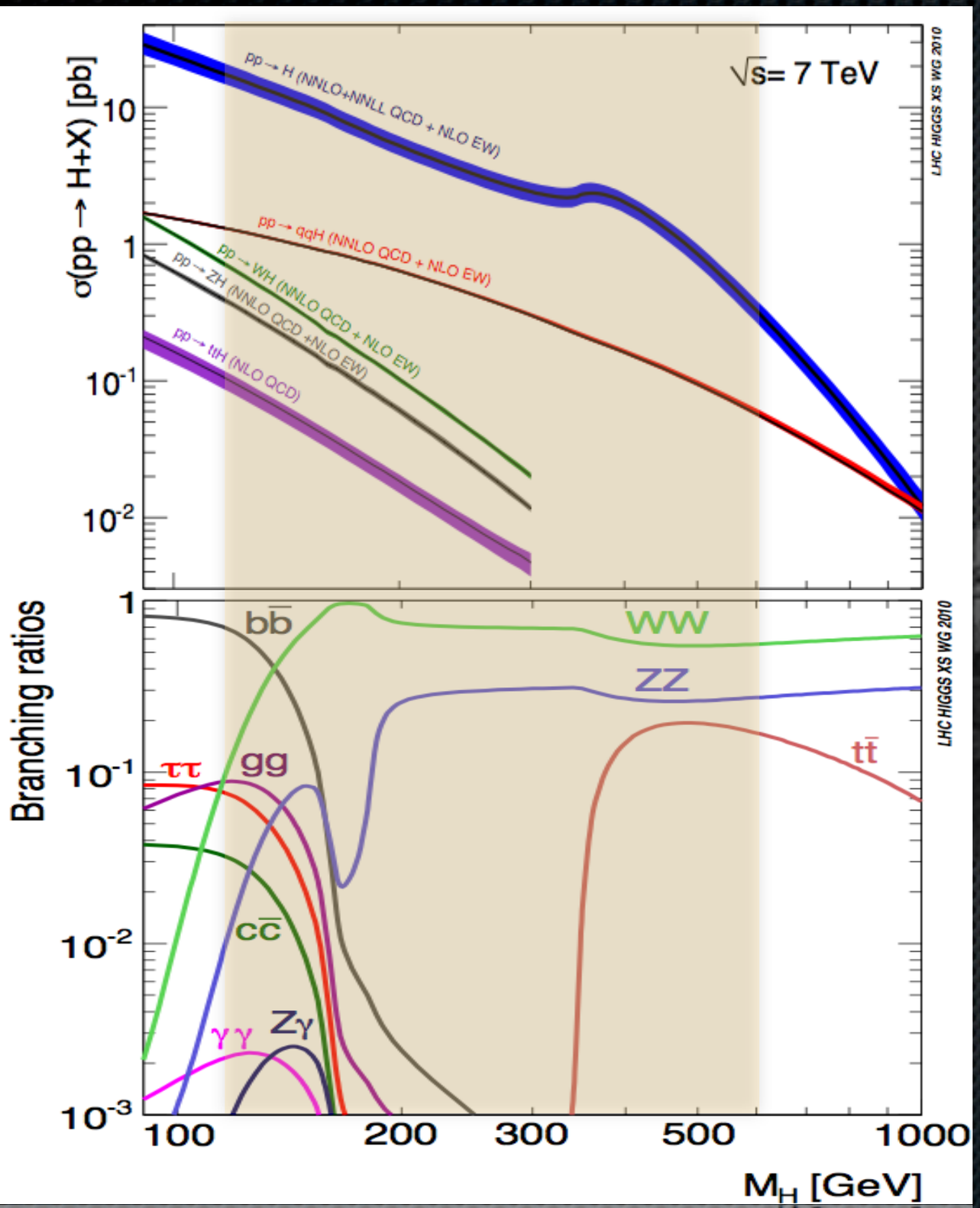


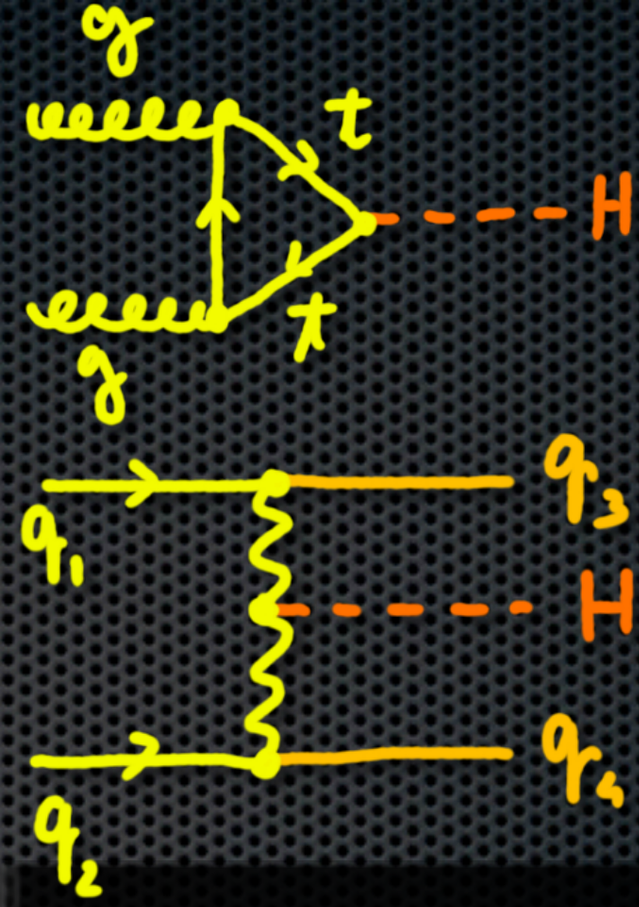
H → ZZ → llνν: Exclusion limit



- **A SM Higgs boson is excluded at 95% CL in the mass range:**
  - **340 GeV < m_H < 450 GeV**
  - **Lowest expected limit (1.1 × σ_{SM}) at m_H ~ 380 GeV**

m_H = 110-600 GeV



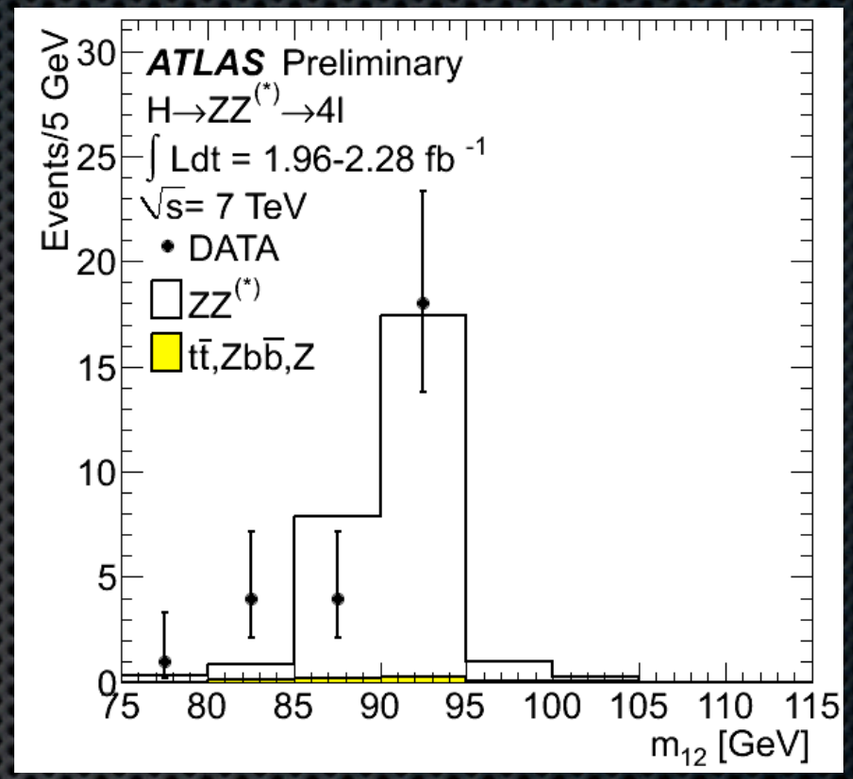


$H \to ZZ \to 1111$

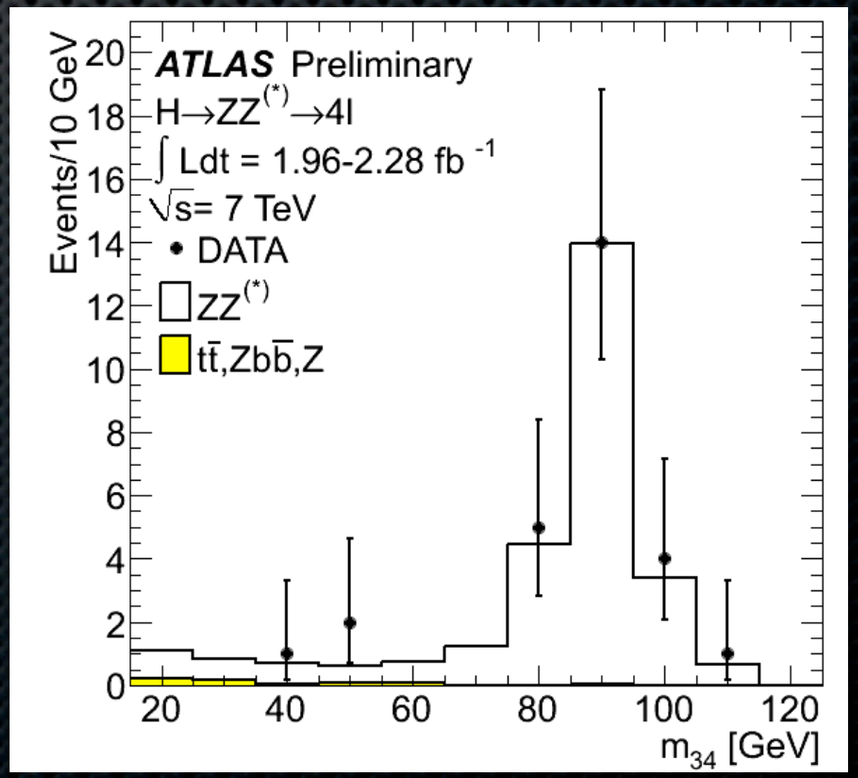
- The **Golden** channel
  - Very clean but small rates
  - Usable in the full mass range
- Analysis similar to SM *ZZ*
  - Lower lepton momenta
- SM *ZZ*: irreducible background

H → ZZ → llll: Event Selection

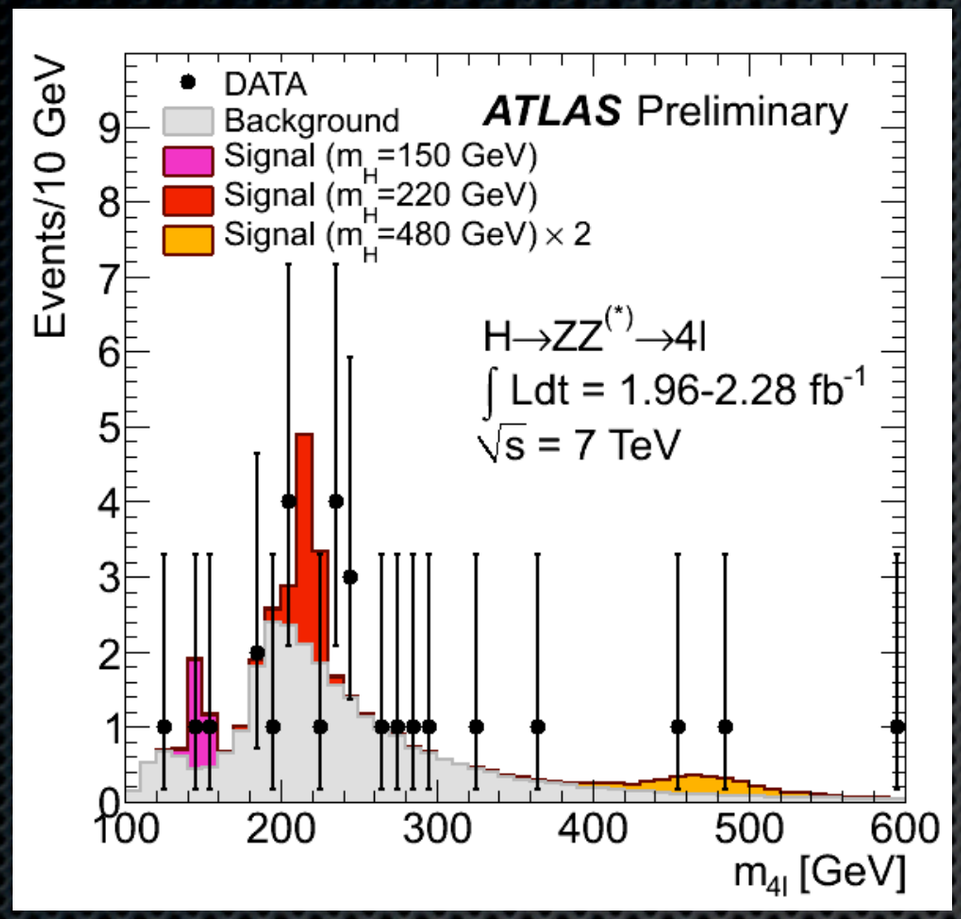
- **Event Selection**
  - Two same flavor OS pair of isolated leptons
  - Invariant mass cuts
    - $|m_{12} - m_Z| < 15$ GeV
    - $m_{34} < 115$ GeV and veto low mass pairs
  - For m4l < 190 GeV:
    - lepton impact parameter small

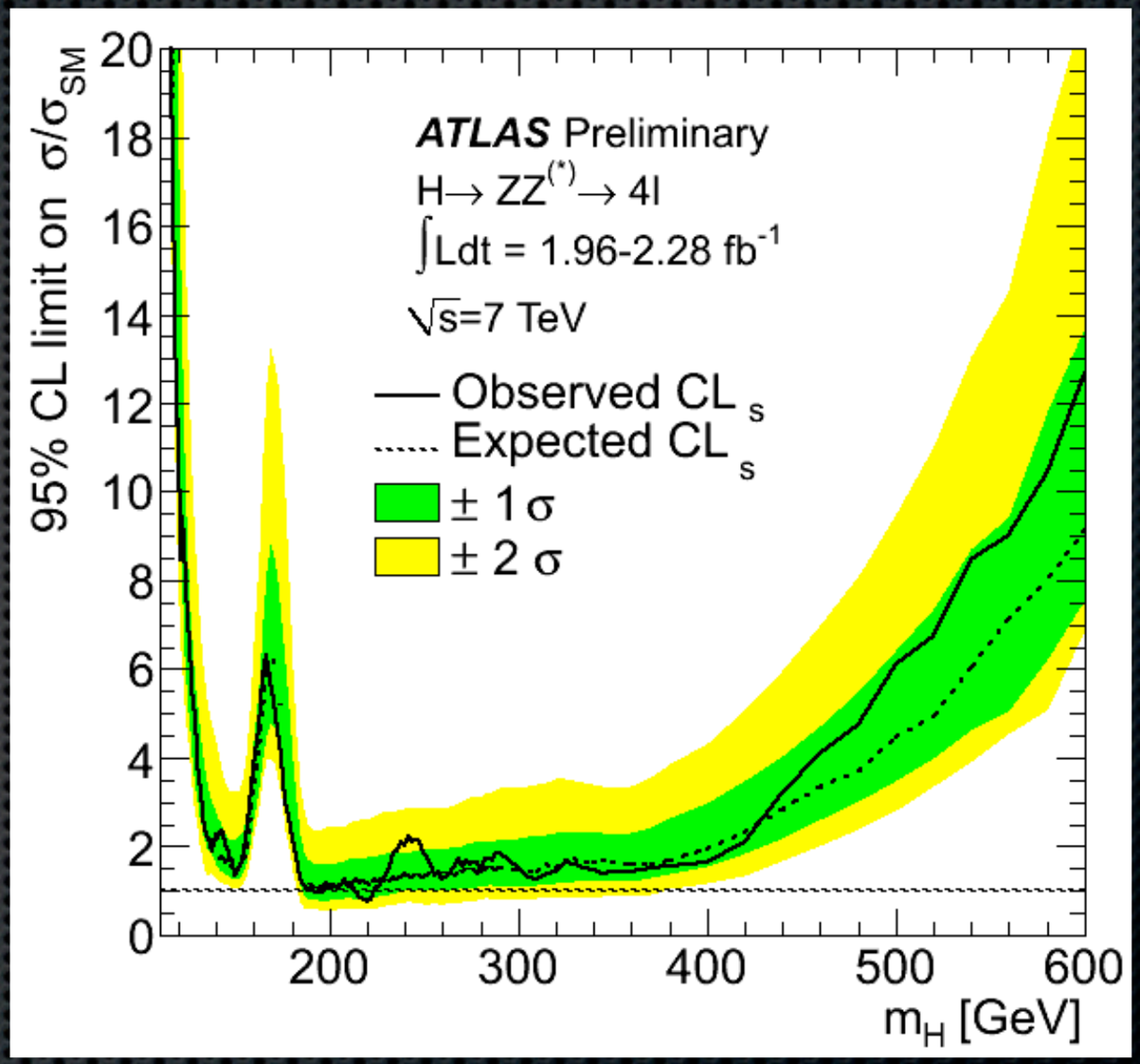


- **Backgrounds**
  - ZZ and top from MC prediction
    - Uncertainty: 10-15%
  - Z+jets normalized to data using control regions
    - (no isolation/impact parameter)
    - Uncertainty: 20-40%



H → ZZ → llll: Limit

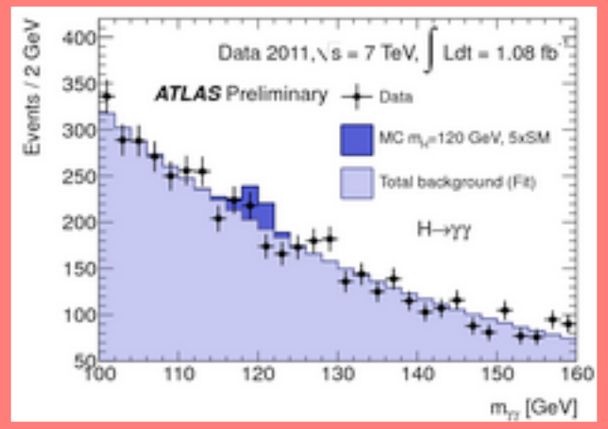


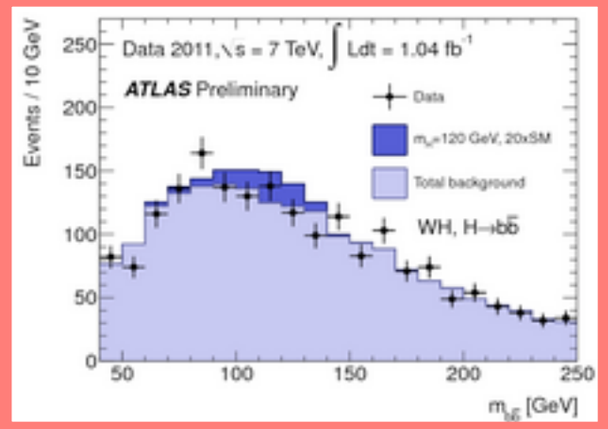


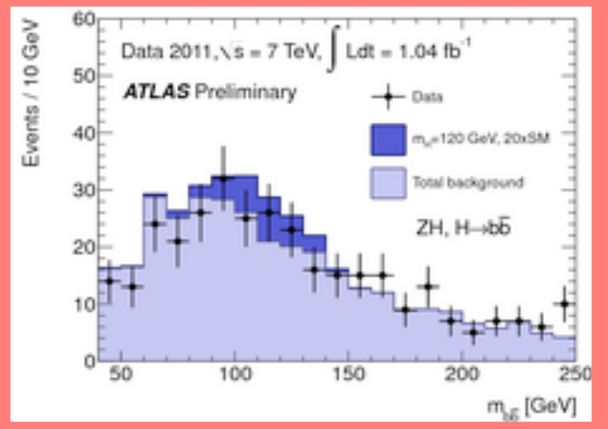
Selected: 27 events (6ee, 9eμ, 12μμ)

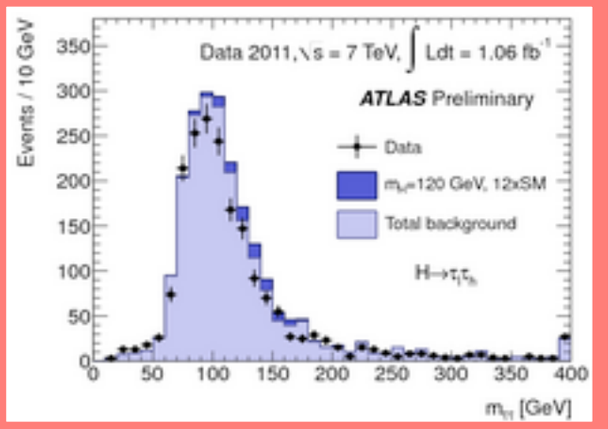
- **Limit very close to the SM cross section for a wide range of Higgs masses**
  - **Small region for M_H ~ 210 GeV excluded at 95% C.L.**

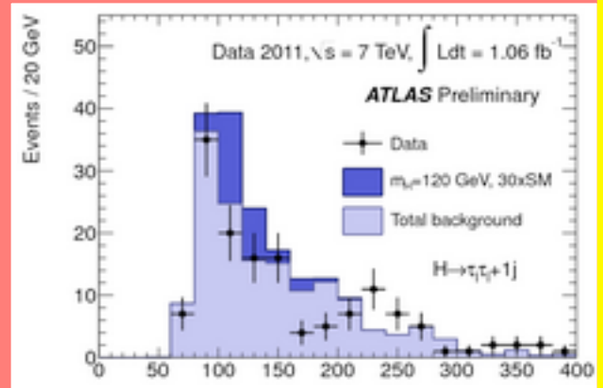
ATLAS SM Higgs Combination

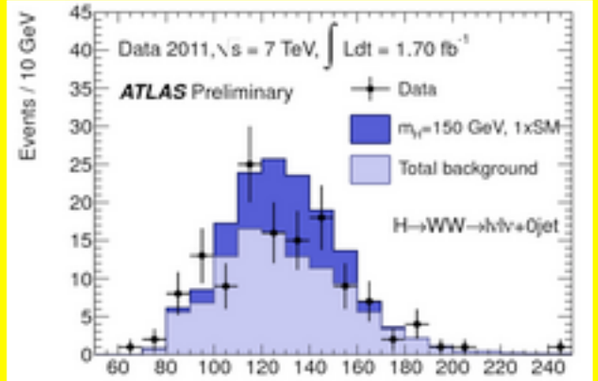


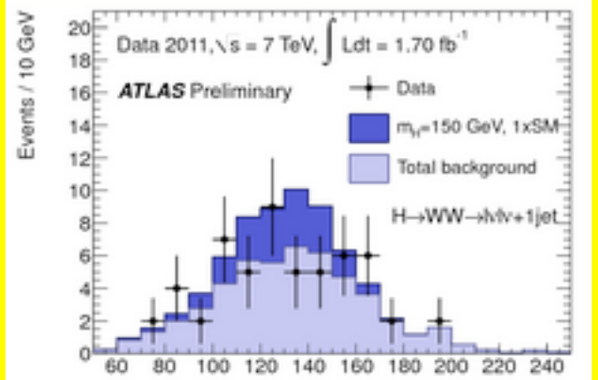


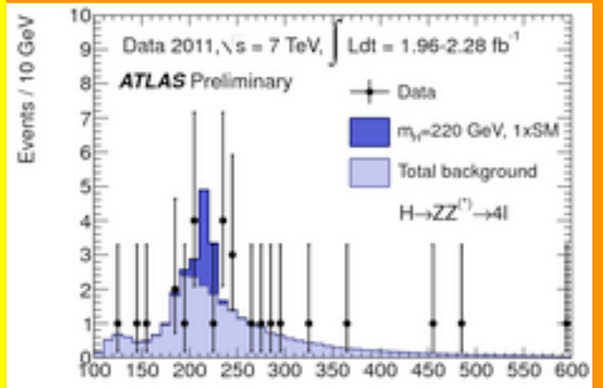


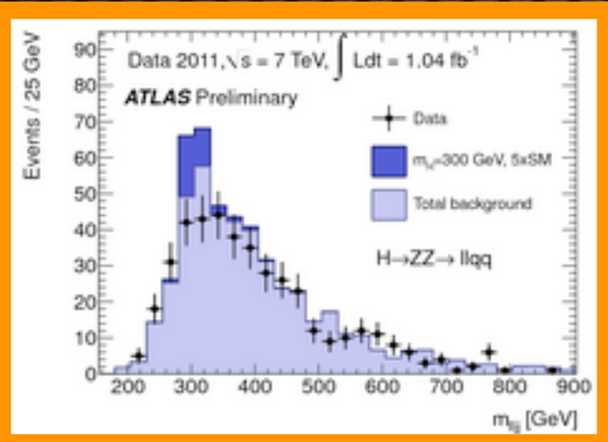


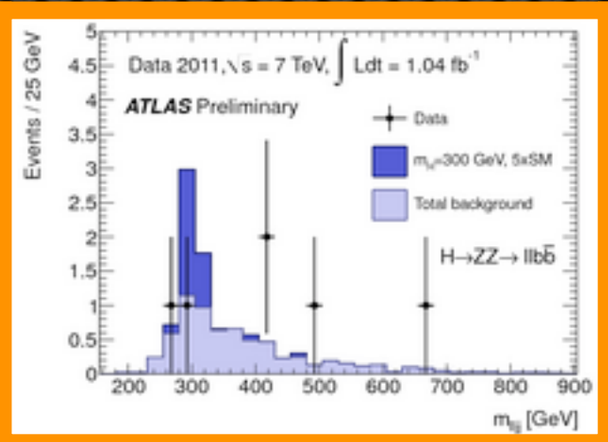


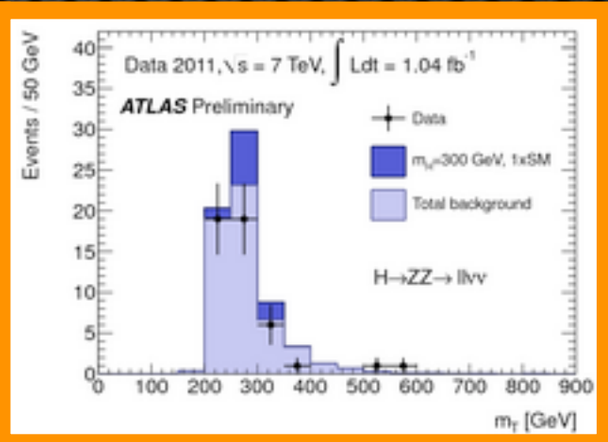


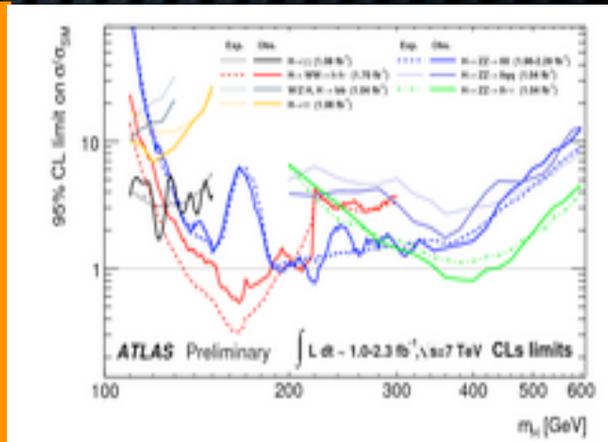




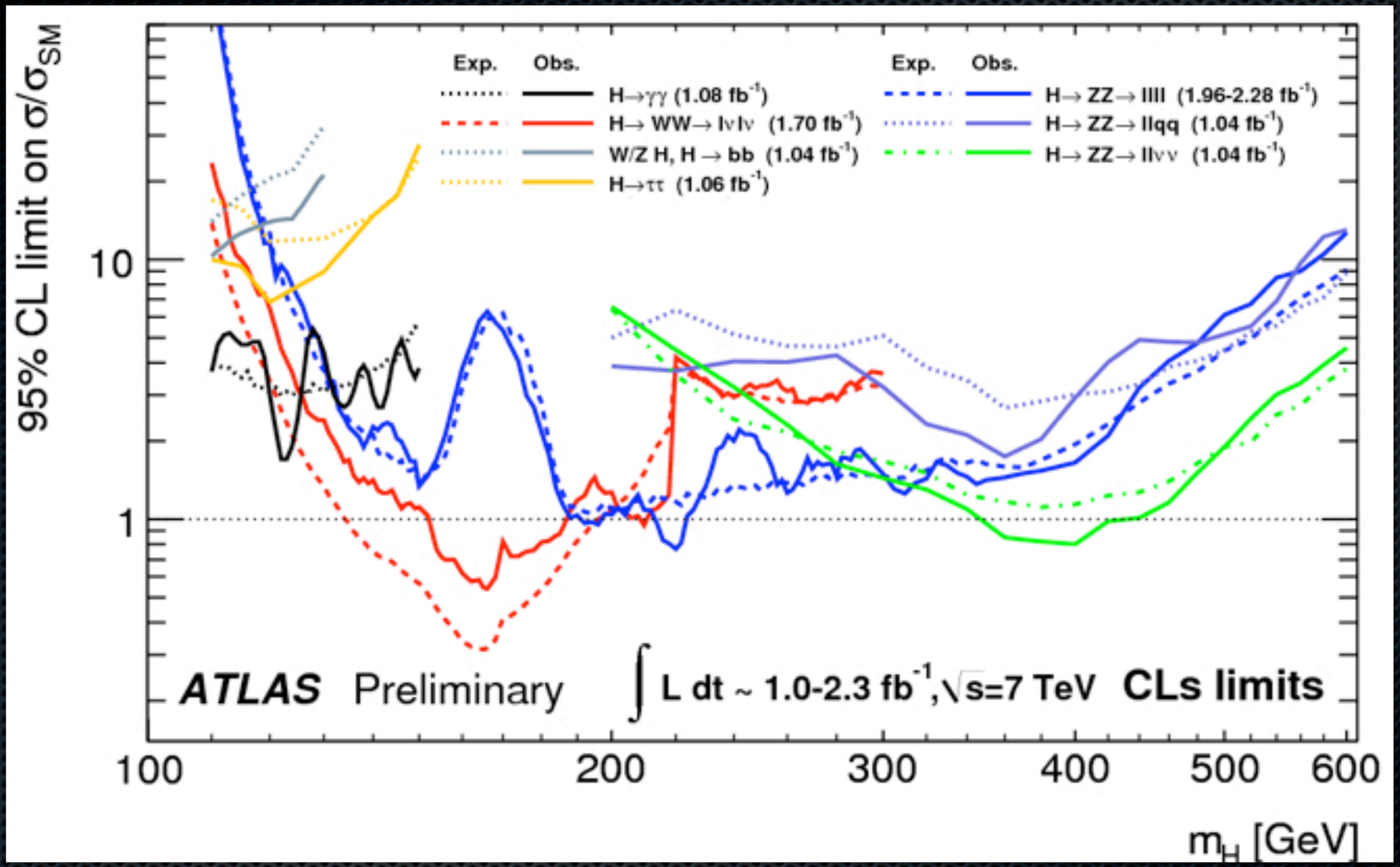






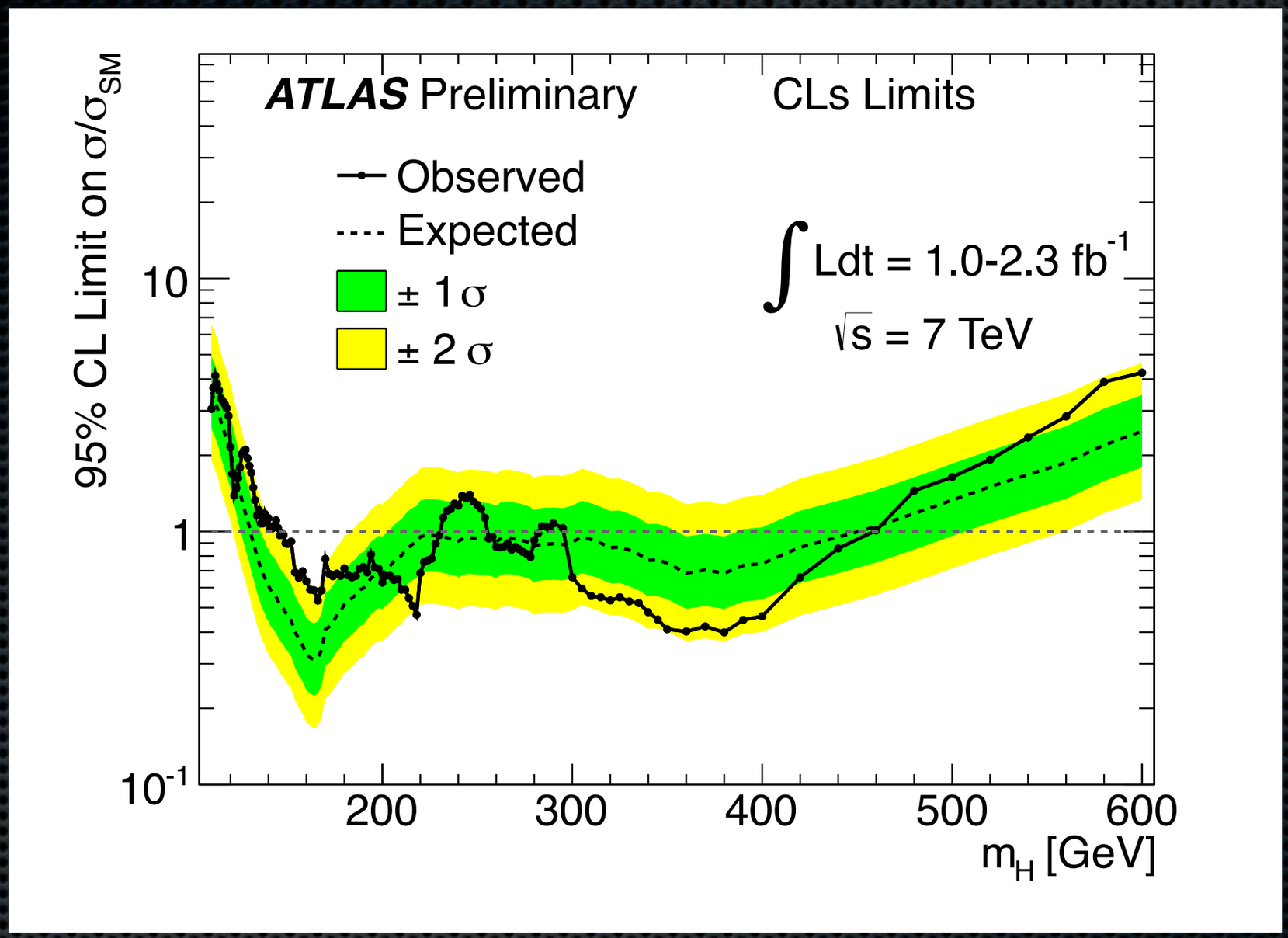


ATLAS SM Higgs Combination



- **Correlated uncertainties taken into account**
  - **Jet energy scale, luminosity, PDF, etc**
- **Uncorrelated uncertainties:**
  - **Backgrounds estimated by data driven methods**

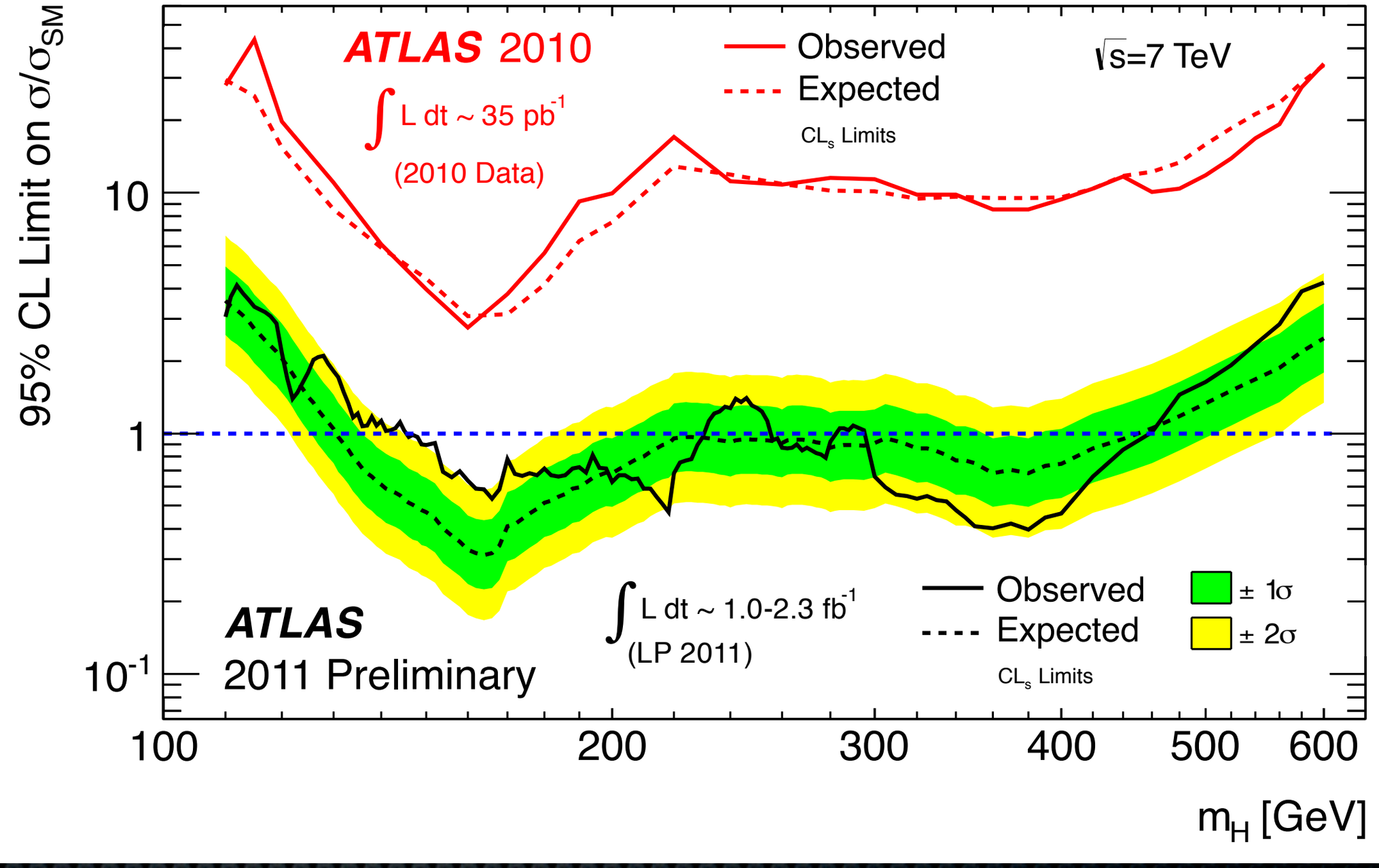
ATLAS Higgs Combination Result



- **Exclusion limits at 95% C.L.**
  - **$146 < m_H < 232$ GeV**
  - **$256 < m_H < 282$ GeV**
  - **$296 < m_H < 466$ GeV**

- **Exclusion at ~99% C.L.**
  - **$160 < m_H < 220$ GeV**
- **Exclusion > 99% C.L.**
  - **$300 < m_H < 420$ GeV**

Improvements with Time



Conclusions

- **ATLAS has analyzed up to 2.3 fb^{-1} of data to perform Higgs searches and study Standard Model diboson production**
  - **Excellent agreement with Standard Model predictions has been observed in all cross section measurements**
    - **$\gamma\gamma$, $W\gamma$,$Z\gamma$, WW, WZ and ZZ**

- **Data already allows for stringent constraints on the Standard Model Higgs boson production**
  - **Exclusion limits at 95% C.L.**
    - **$146 < m_H < 232$ GeV**
    - **$256 < m_H < 282$ GeV**
    - **$296 < m_H < 466$ GeV**

- **No significant excess observed**
  - **Largest excess of the order of 2.1σ**

Expected improvements and prospects

- **More data:**
  - ~ 4 fb^{-1} by end of 2011 and ~10 fb^{-1} by end of 2012
- **Refine understanding of detector response:**
  - Alignment, calibration, comparison with simulation
  - Better performance, smaller systematic uncertainties and higher efficiency for rare channels
- **More precise measurements of SM processes**
  - Additional contraints on MC generators
- **More sophisticated analyses:**
  - Multivariant techniques
  - Additional discriminating variables (p_T, angular distributions)
  - Exclusive channels (e.g. $H \rightarrow \tau\tau$ (VBF))

Expectations: ATLAS + CMS

(luminosity numbers per experiment)

4 fb^{-1}: may exclude full region up to m_H ~600 GeV (95% CL)

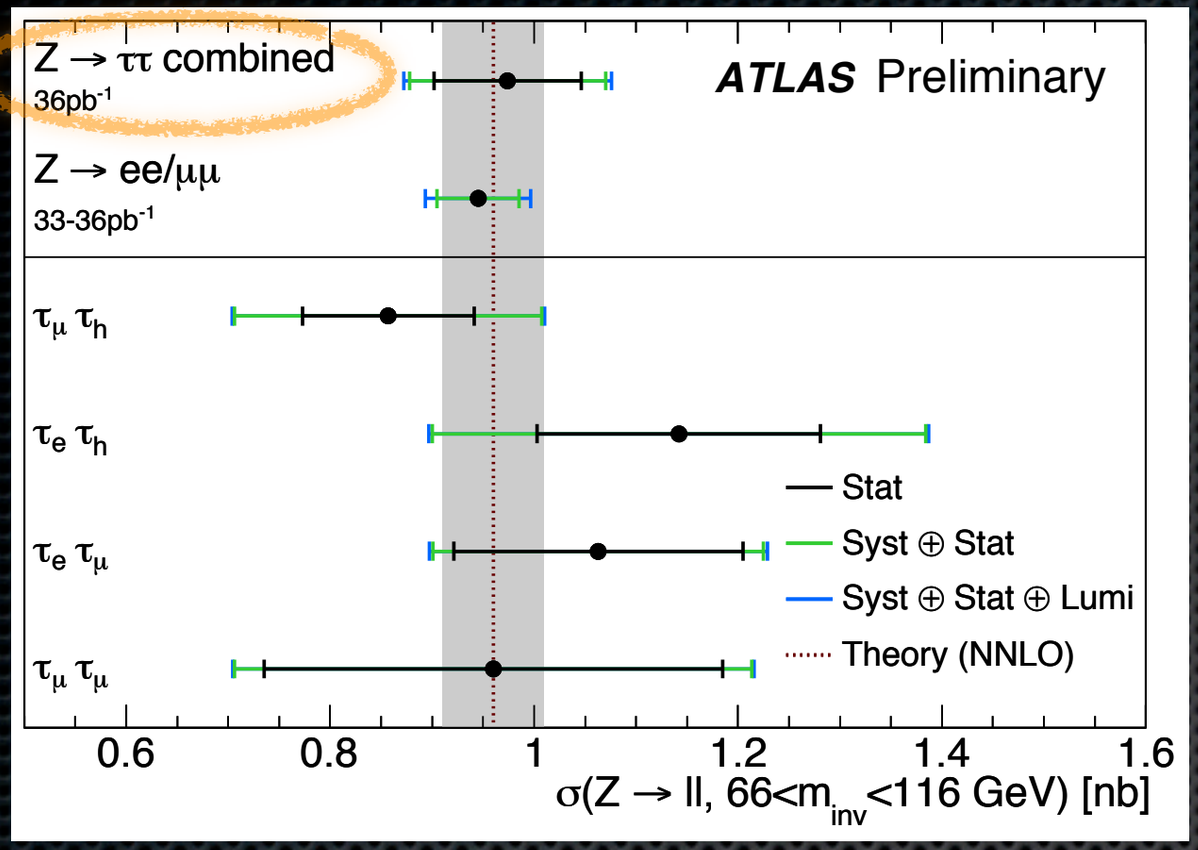
10 fb^{-1}: 5σ discovery potential for m_H > 117 GeV (may reach 114 GeV)

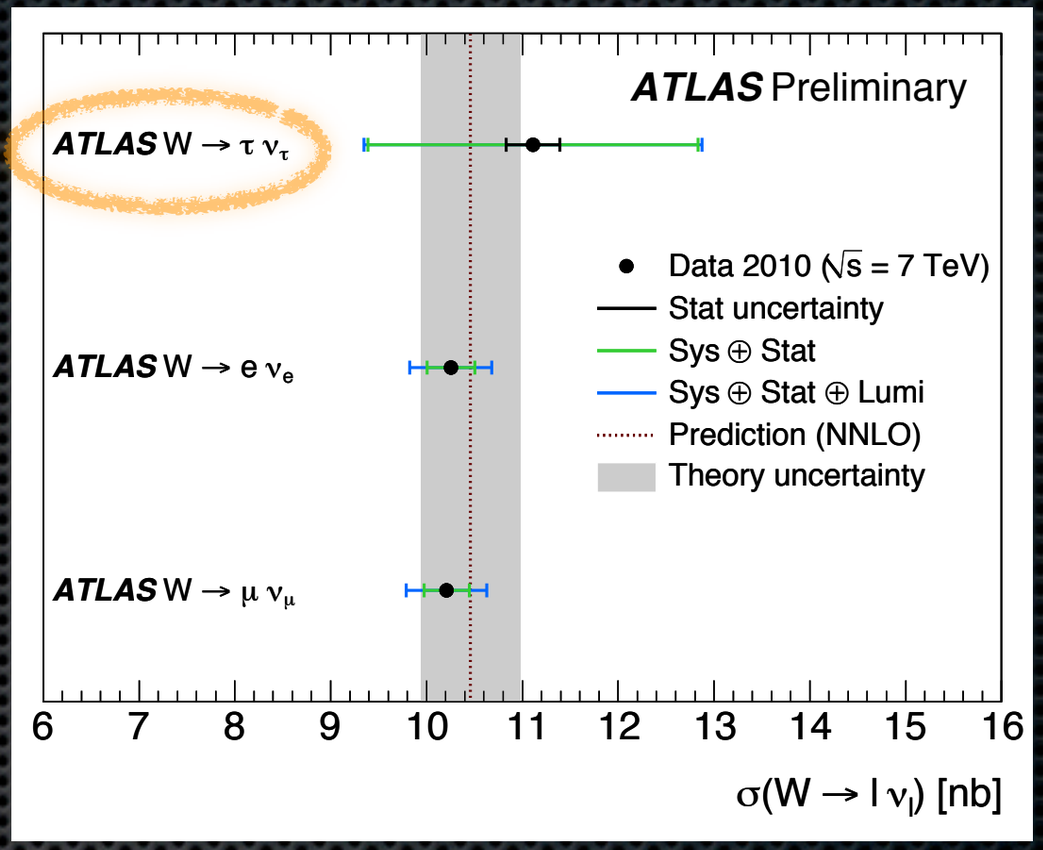
Analyses Covered in this Talk

Higgs	$\mathscr{L}$ (fb^{-1})	Documentation
$H \to WW \to l^+\nu\, l^-\nu$	1.7	ATLAS-CONF-2011-134
$H \to WW \to l\nu qq$	1.04	arXiv: 1109.3615
$H \to ZZ \to l^+l^-\, l^+l^-$	2.0 - 2.3	--
$H \to ZZ \to l^+l^-\, \nu\nu$	1.04	arXiv:1109.3357
$H \to ZZ \to l^+l^-\, qq$	1.04	arXiv:1108.5064
$H \to \gamma\gamma$	1.08	arXiv: 1108.5895
$H \to \tau\tau \to l\tau_{had}3\nu$	1.06	ATLAS-CONF-2011-132
$H \to \tau\tau \to l^+l^-4\nu$	1.06	ATLAS-CONF-2011-133
$W/Z + (H \to bb)$	1.04	ATLAS-CONF-2011-103

Dibosons	$\mathscr{L}$ (fb^{-1}	Documentation
$\gamma\gamma$	0.037	arXiv: 1107.0581
$W\gamma/Z\gamma$	0.035	arXiv: 1106.1592v2
$WW \to l^+\nu\, l^-\nu$	1.02	ATLAS_CONF_2011_110
$WZ \to lll\nu$	1.02	ATLAS_CONF_2011_099
$ZZ \to l^+l^-l^+l^-$	1.02	ATLAS_CONF_2011_107

Z→ττ and W→τν Cross Section



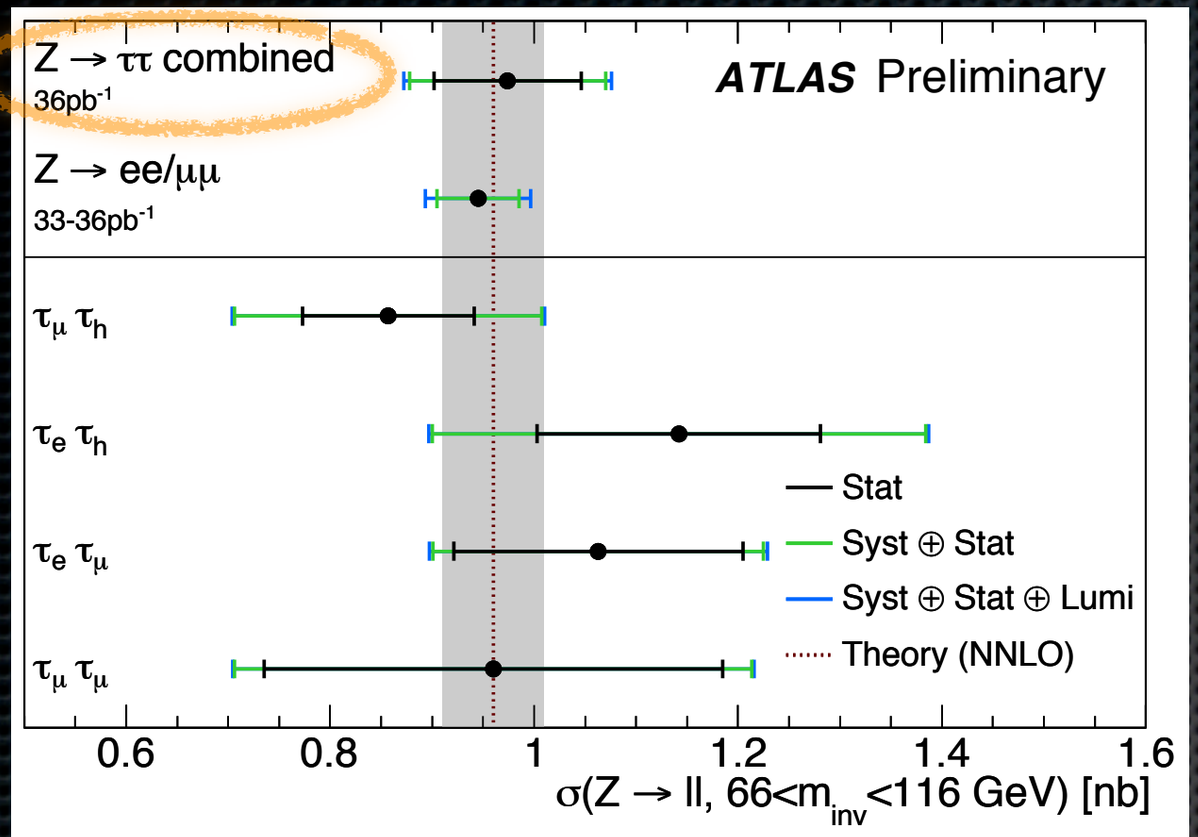


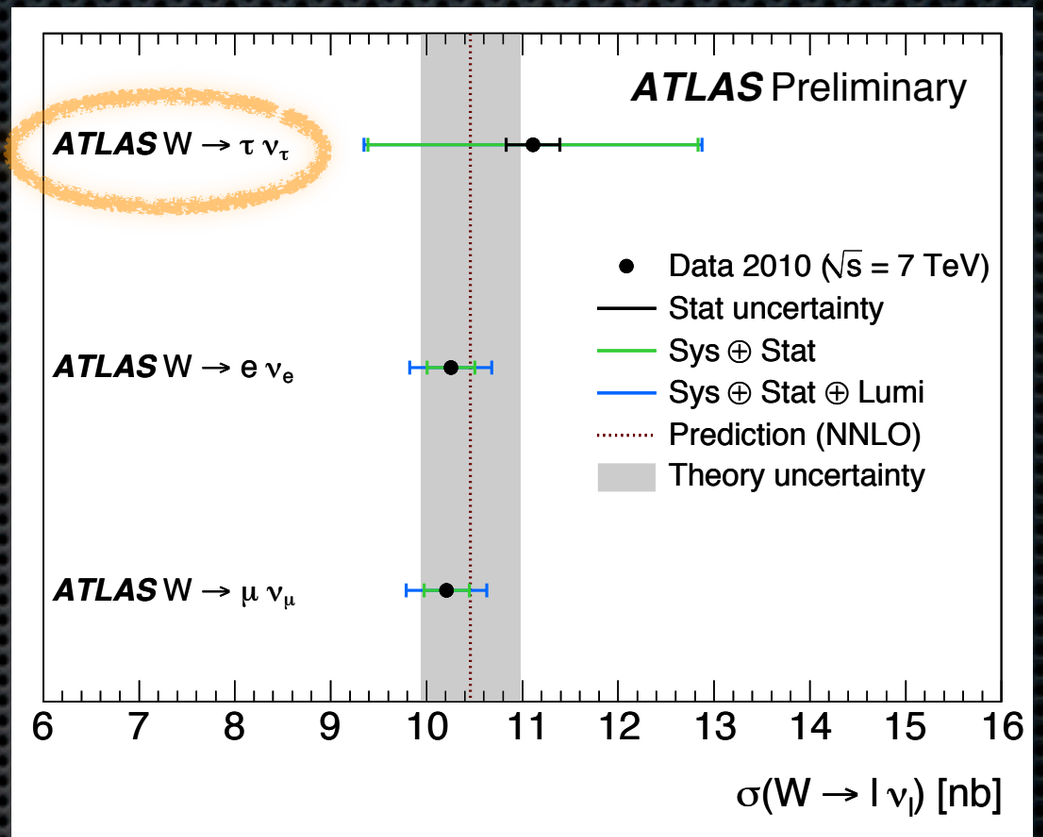
Excellent tau identification at ATLAS

- **Z→ττ cross section**
- **W→τν cross section**

Good prospects for new physics searches with taus

Z→ττ and W→τν Cross Section

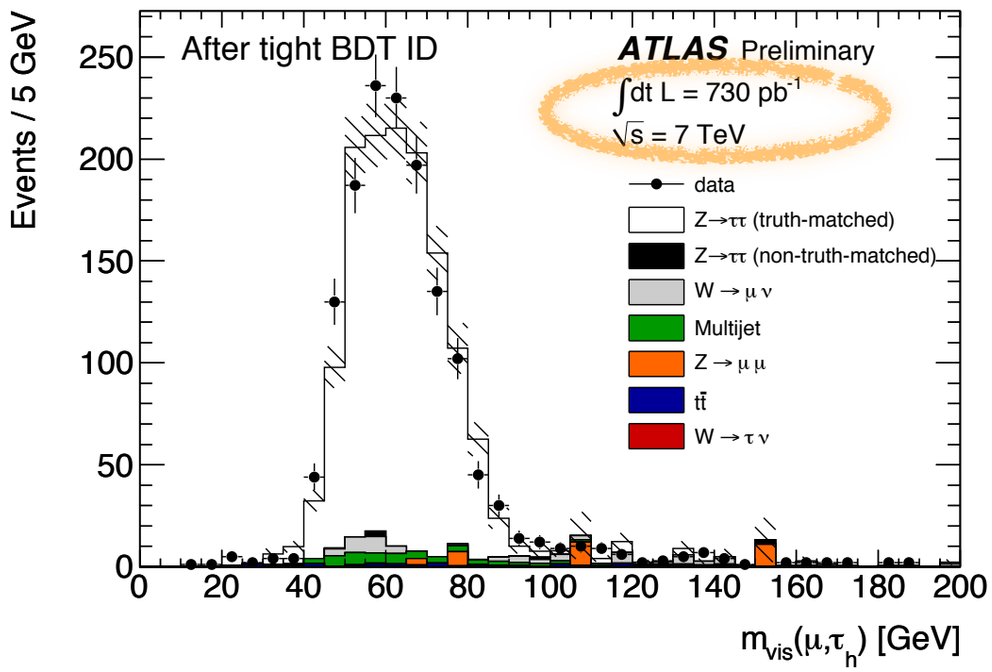




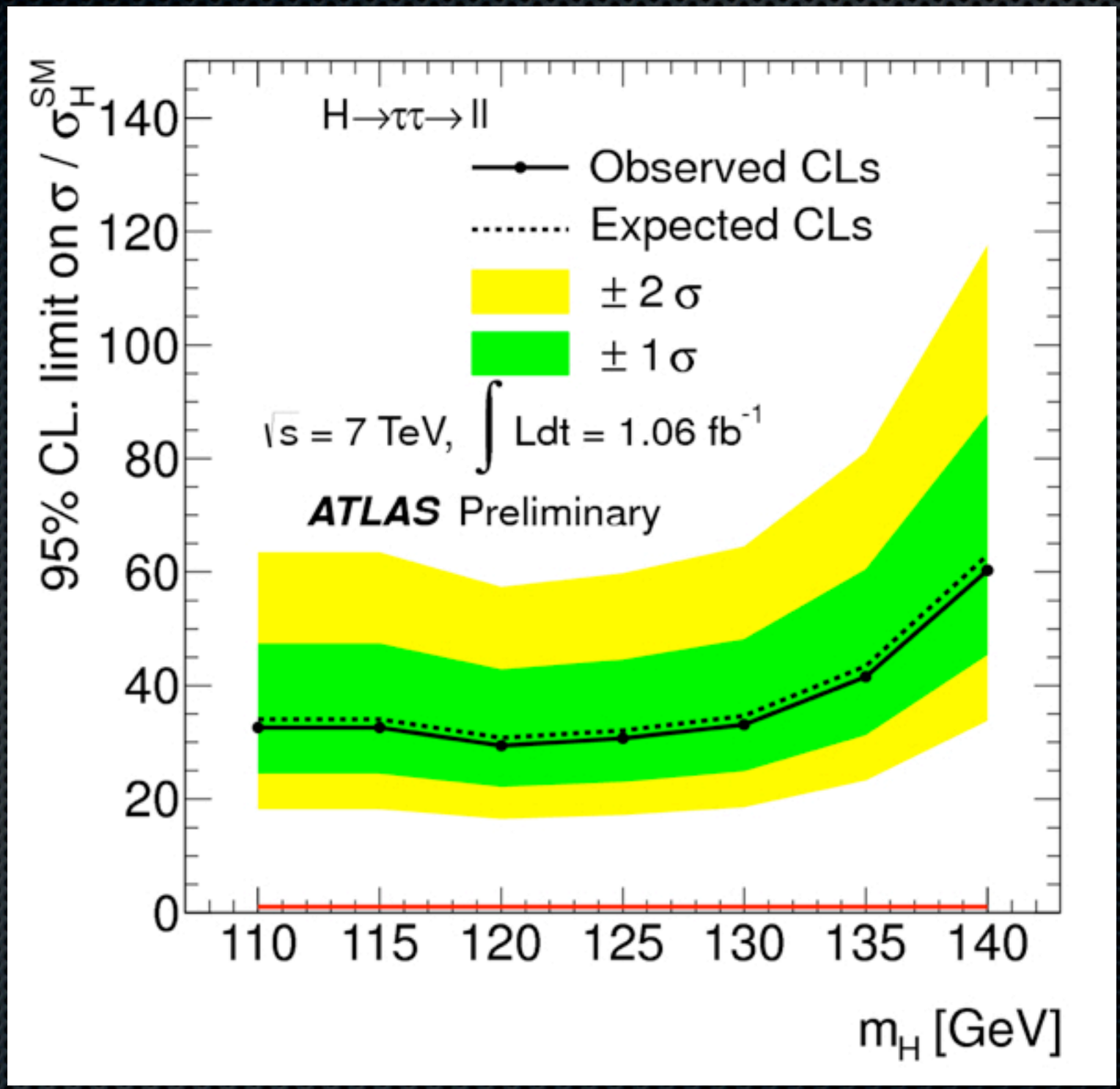
Excellent tau identification at ATLAS

- Z→ττ cross section
- W→τν cross section

Good prospects for new physics searches with taus

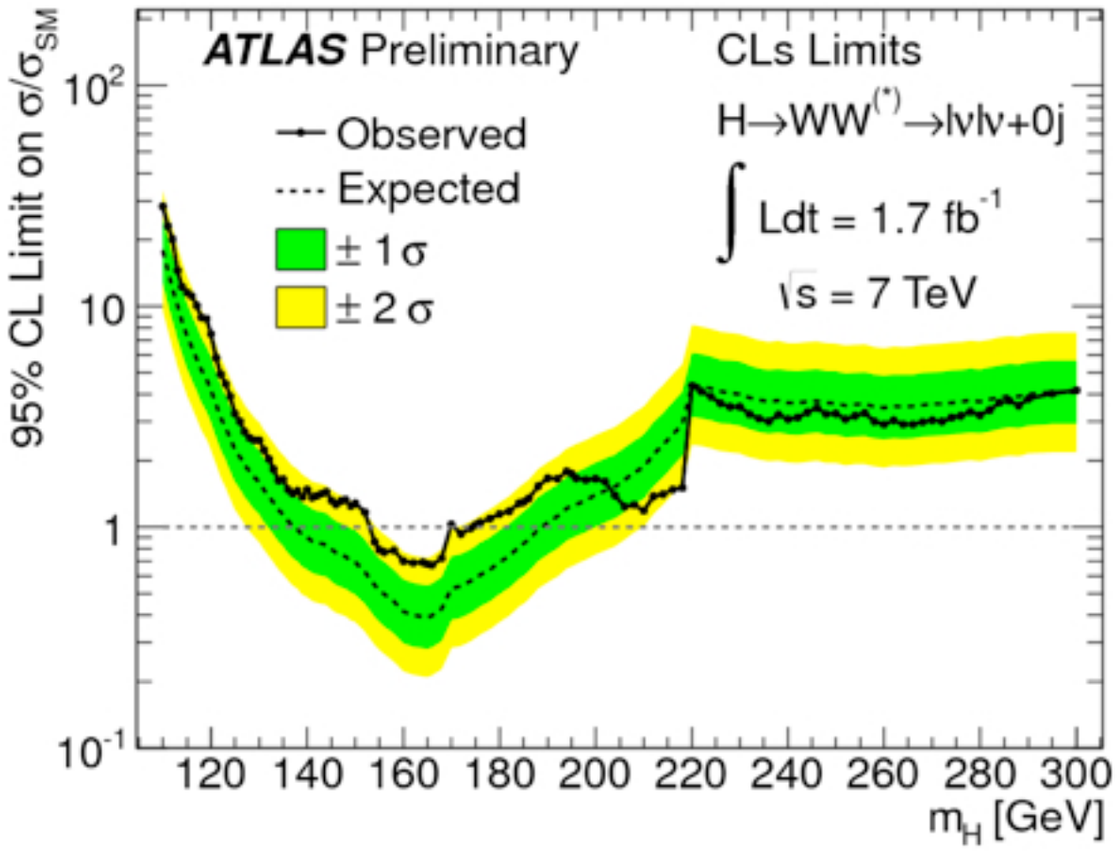
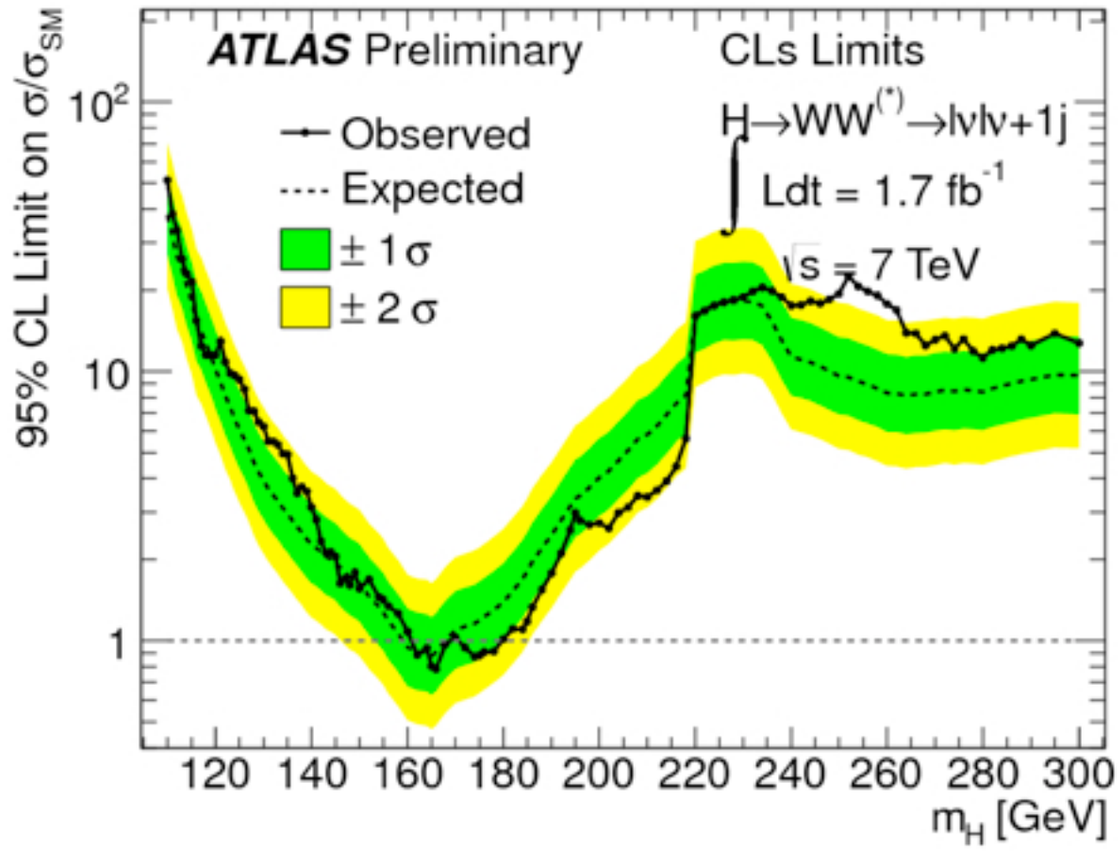


H → ττ → ll+4ν: Exclusion limit



H → WW → lνlν: Exclusion limits

0-jet channel



1-jet channel